Dec. 2, 1969 F. A. MATHAMEL 3,482,118

CURRENT DRIVER

Filed Jan. 10, 1966

Fig. 1.

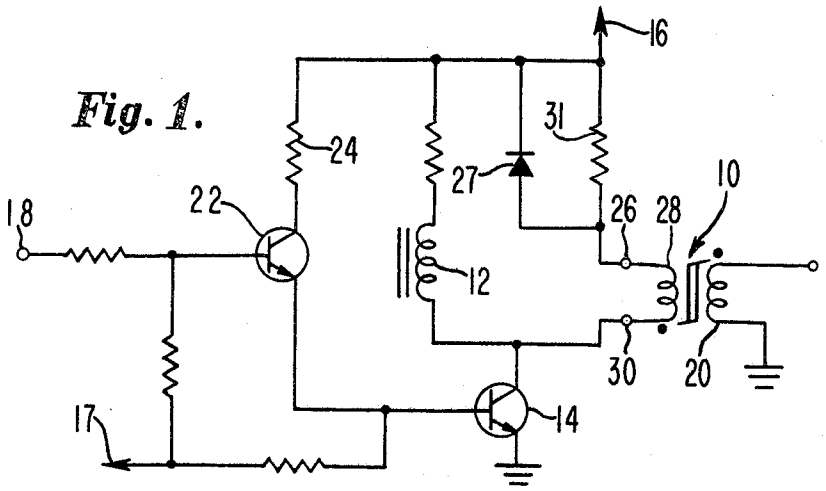


Fig. 2.

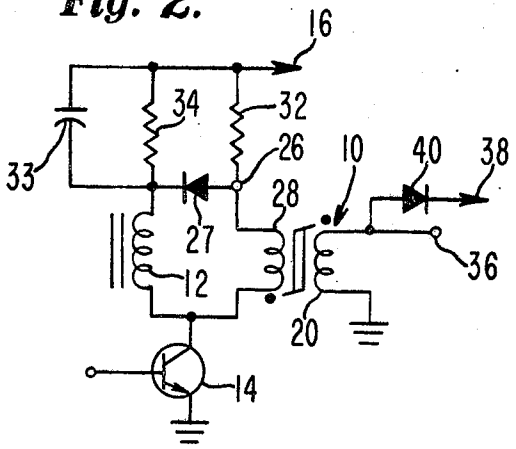


Fig. 3.

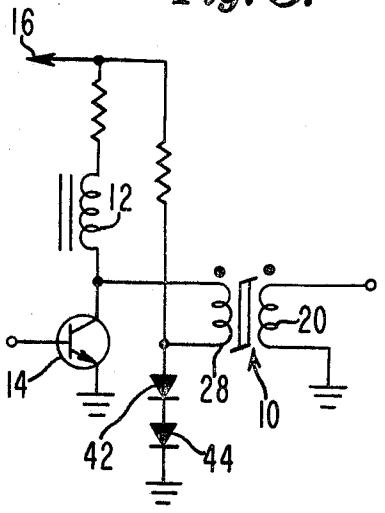
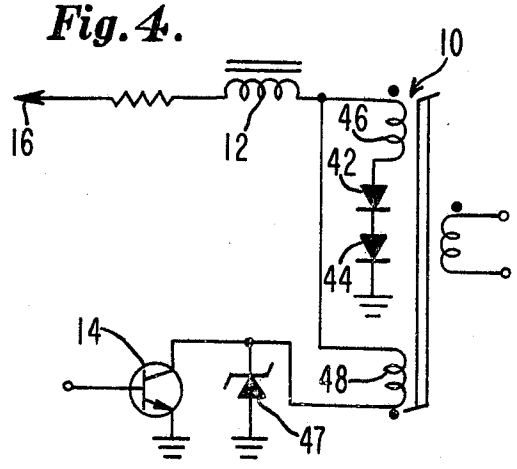


Fig. 4.



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CURRENT DRIVER

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Int. Cl. H03k 3/02

U.S. Cl. 307—270 4 Claims

ABSTRACT OF THE DISCLOSURE

A current driver circuit for providing a high energy current pulse from an inductor to the input winding of a plurality of ferromagnetic cores. Each core has an input winding which is used to set or reset the core depending upon the direction of current flow through the winding and an output winding. A low power transistor controls the direction of current flow through the input winding. A unidirectional control member provides a low impedance current path between the inductor and the input winding for setting the core when the transistor is non-conducting and the control member provides a high impedance current path for resetting the core when the transistor is conducting.

This invention relates to apparatus for providing intermittent pulses of power to a utility device, and more particularly, to a current driver for providing current pulses to ferromagnetic cores so as to switch them from one state to the other.

It is frequently desirable to switch ferromagnetic cores from one state to another. For example, in the patent application to Narendra M. Shukla, Ser. No. 472,425, filed July 16, 1965, a current driver is disclosed for use in switching ferromagnetic cores that are part of the keyboard of a business machine. These ferromagnetic cores are normally inhibited from switching by a permanent magnet located close to them. However, whenever a key on the keyboard is depressed, the flux from the permanent magnet is diverted so that the core is no longer inhibited and it is caused to switch from one state to the other by current from a current driver. As the cores switch from state to state, they generate a voltage in an output winding around one of the cores. This voltage indicates which key of the keyboard has been depressed.

The current driver disclosed in the aforementioned application to Narendra M. Shukla stores energy in an inductive coil whenever pulses are not being applied to set the ferromagnetic cores. Whenever it is desired to set the cores, the circuit containing the inductor is opened. Electrical energy previously stored in the inductor then forces current through an alternate circuit path to the set windings of the cores. Another constantly flowing current, having a magnitude less than that provided by the coil, resets the ferromagnetic cores between the times that current pulses are provided by the inductor to set the cores.

The current driver described in the aforementioned patent application to Narendra M. Shukla has several advantages. It does not require a high output impedance to efficiently drive the cores. Also, it does not require an A.C. driver or two D.C. drivers to set and reset the cores by applying currents of opposite polarity to the windings. Furthermore, low-priced, low-power transistors may be used in the current driver because it does not require a high output impedance and because energy is stored in an inductor prior to its use.

The current drivers described in the instant application are improvements upon the current driver disclosed by Narendra M. Shukla in the above-mentioned patent application. Accordingly, it is an object of this invention to provide an improved current driver for switching ferromagnetic cores from one state to another.

It is a further object of this invention to provide the current driver which is reliable and economical in operation.

In accordance with the above objects, a current driver is provided having a source of voltage, an inductor, and a switch. Current flows from the source of voltage through the inductor, and through the switch to ground. It also flows in a first direction through the input windings on the ferromagnetic cores and from there through the switch to ground. This current builds a field in the inductor and resets the cores. When the switch is opened to interrupt the current flow, the inductor discharges and current flows through the input windings on the ferromagnetic cores in the opposite direction.

The current discharged from the inductor sets the ferromagnetic cores since it flows through the input windings in a direction opposite to the first direction. When the switch is closed again, the current flowing from the voltage source through the input winding of the ferromagnetic core again resets the cores. A capacitor or a diode may be connected between the input winding of the ferromagnetic core and the source of voltage to reduce the high voltage that normally appears at one terminal of the switch whenever it is opened and the inductor discharged.

The invention and the above noted and other features thereof will be understood more fully and completely from the following detailed description considered in connection with the accompanying drawings in which:

FIG. 1 is a schematic circuit diagram of one embodiment of the invention utilizing a diode shunt and a common path for the core resetting current and the inductor discharging current;

FIG. 2 is a schematic circuit diagram of another embodiment of the invention using another form of diode shunt and using a common current path;

FIG. 3 is a schematic circuit diagram of another embodiment of the invention using separate current paths for the inductor charging current and the core resetting current; and

FIG. 4 is a schematic circuit diagram of another embodiment of the invention using separate set and reset windings.

In FIG. 1 a schematic circuit diagram of a pulse generator for setting and resetting a ferromagnetic core **10** is shown having a current storage member such as an inductor **12**, a switch such as a transistor **14** and a first source of voltage **16**. An input terminal **18** receives synchronized clocked pulses which trigger the pulse generator causing it to switch the ferromagnetic core **10** through one complete cycle. This provides a synchronized output on the output winding **20** of the core **10**. The negative clock pulses bias the input NPN transistor **22** to cut off by biasing its base electrode negative. Since its collector is electrically connected to the first source of voltage **16** through a resistor **24**, this voltage is normally partially applied to the base of NPN transistor **14** from the emitter of the transistor **22**. However, when the transistor **22** is cut off, the base of the transistor **14** is biased negative by the negative voltage source **17**. This causes the transistor **14** to be cut off, in which condition it operates as an open switch.

Current normally flows from the source **16** through a first terminal **26** of the input winding **28** of the core

10. This current flows through the input winding 28, through a second terminal 30 to the collector of the transistor 14 and then to a second source of voltage or ground through the transistor. At the same time, current flows from the source 16 through the inductor 12 to the collector of the transistor 14 and then to ground. This current builds up a strong field in the inductor 12.

Negative clock pulses applied to terminal 18 cause the transistor 22 to be cut off which, in turn, causes the transistor 14 to be cut off. When the transistor 14 is cut off, the field in the inductor 12 automatically, i.e., without requiring additional signals, collapses, forcing current through the input winding 28 of the ferromagnetic core 10 in the opposite direction from which it was flowing when the transistor 14 was conductive. As the inductor 12 discharges, current flows through the input winding 28 from terminal 30 to terminal 26 causing the core 10 to be set. At this time the core 10 generates an output pulse in the winding 20.

When the inductor 12 discharges, it generates a high voltage at the collector of the transistor 14. This high voltage is damaging to some transistors. To prevent the transistors from being burned out, a unidirectional control member or diode 27 has its anode electrically connected to terminal 26 and its cathode electrically connected to the source of voltage 16. This diode reduces the voltage at the collector of the transistor 14 by an amount equal to the set current multiplied by the resistance of a resistor 31 that connects terminal 26 to the voltage source 16. The diode 27 also reduces the energy which is taken from the inductor 12 for the set function.

In FIG. 2 a schematic circuit diagram of another embodiment of the invention is shown in which the shunting diode 27 has its anode connected between terminal 26 of the input winding 28 and one end of a resistor 32. The other end of the resistor 32 is connected to the voltage source 16. The cathode of the diode 27 is connected between the inductor 12 and one end of a resistor 34. The other end of the resistor 34 is also connected to the voltage source 16. Furthermore, one end of the output winding 20 is grounded and its other end is connected to the output terminal 36. The end connected to the output terminal 36 is also clamped to a source of positive voltage 38 by a diode 40 which has its anode electrically connected to the terminal 36 and its cathode electrically connected to the positive voltage source 38.

As in the circuit of FIG. 1, a normal resetting current flows from the source 16 through both the input winding 28 and the inductor 12 through parallel paths to the collector of the transistor 14 and from there to ground. However, a negative input pulse applied from the input transistor to the base of the transistor 14 interrupts this current causing the field in the inductor 12 to collapse driving current in the opposite direction through the input winding 28 to set the core 10. In FIG. 2 this setting current is conducted back to the other end of the inductor 12 through the diode 27 and does not flow through the resistance 34. The voltage at the collector of the transistor 14 may be controlled by adjusting the ratio of the turns of the winding 28 to the turns of the winding 20. The voltage at the collector is equal to the output voltages times this ratio. If several cores are driven by the same current driver, the output voltage times the coil ratios for each of them are added together. The output voltage is clamped to the level of the voltage source 38. Actually, it will be slightly above this because of the forward voltage drop across the diode 40. The core 10 is reset in the same manner as it was in FIG. 1. The capacitor 33 maintains the potential at the junction of inductor 12 and resistor 34 during set time.

In FIG. 3 a schematic circuit diagram of another embodiment of the invention is shown having a ferromagnetic core 10 with an input winding 28 and an output winding 20. However, unlike the prior embodiments, one end of the input winding 28 is connected to ground through an impedance member which is shown as the forward resistance of the two series connected diodes 42 and 44. The other end of the input winding 28 is electrically connected to the collector of the transistor 14 and also one end of the inductor 12. The other end of the inductor 12 is electrically connected to the source voltage 16 as is the anode of diode 42.

As in the prior embodiments, the current from the positive voltage source 16 follows two parallel paths, one of which stores energy in the inductor 12 and the other of which applies reset current to the input coil 28. However, in the embodiment of FIG. 3, the resetting current flows through the transistor 14 and the current for setting the core 10 flows through the diodes 42 and 44. Current also flows through the inductor 12 and the transistor 14 during reset time. When the transistor 14 is cut off, the inductor 12 discharges into the winding 28 in the opposite direction that the current from the source 16 has been taking to reset the core 10. As the inductor 12 discharges through the winding 28, the core 10 is set.

In FIG. 4 another embodiment of the invention is shown, which embodiment of the invention uses two input windings: a set winding 46 and a reset winding 48. One end of each of the windings 46 and 48 is electrically connected to one end of the inductor 12, the other end of the inductor 12 being connected to the source of positive voltage 16. The other end of the set winding 46 is connected to ground through the forwarded resistance of the series connected diodes 42 and 44; the other end of the reset winding 48 is connected to the collector of the transistor 14 and to the cathode of Zener diode 47. The anode of the Zener diode 47 is grounded so that it provides voltage protection for the transistor 14. This voltage protection is necessary in case a secondary circuit of the core, the output winding, should become open circuited. In such a case, the collector voltage on the transistor 14 would become excessive. However, the Zener diode 47 limits this voltage to a safe maximum level.

In the prior embodiments separate set and reset currents are established by individual resistors that are in series with the inductor 12 and the input winding 28. In FIG. 4, only one current is established and it is applied alternately to set and reset windings. Because of this, the transistor 14 is not required to carry as large a maximum current and an inexpensive transistor may be used.

It can be seen that the current drivers of this invention are reliable and inexpensive. The power demands of the transistors are kept to a minimum so that low cost transistors may be used. Further, the collector voltages of the transistors are reduced to a minimum so as to prevent burning out of low-cost transistors.

Of course, many modifications and variations of the invention are possible in the light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A current control system for the setting and the resetting of a magnetic core comprising:

at least one magnetic core winding electrically connected at a first end thereof in a circuit to a source of direct current,

a current storage member electrically connected at one end thereof to the source of direct current and electrically connected at the other end thereof to the second end of said magnetic core winding, and

a switch member electrically connected between the other end of said current storage member and ground,

said switch member when closed to conduct a flow of current from said direct current source through said winding in a first direction to reset the magnetic core, and

said switch member when opened and in cooperation with said storage member to allow the flow of current

from said current storage member to said winding in a direction opposite to said first direction to automatically set the magnetic core.

2. A current control system for the setting and the resetting of a magnetic core according to claim 1 wherein said current storage member is an inductor.

3. A current driver for switching at least one ferromagnetic core between a first state and a second state comprising:

a set winding on the ferromagnetic core, said set winding having a first and second end,

a reset winding on the ferromagnetic core, said reset winding having a first and second end,

an inductor electrically connected to said first end of said set winding and to said second end of said reset winding,

an impedance member electrically connected between said second end of said set winding and ground, said member adaptable to provide a predetermined fixed voltage drop thereacross, said voltage drop independent of the amount of current flowing therethrough,

a switch member connected between said first end of said reset winding and ground and adapted to conduct current through said reset winding in a first state and to conduct current through said set winding and said impedance member in a second state, and

a Zener diode electrically connected in parallel with said switch member to control the voltage across said switch member.

4. A current driver for switching ferromagnetic cores between a first state and a second state comprising:

an input winding for one of said ferromagnetic cores,

said input winding having a first end electrically connected to a source of voltage and a second end,

an inductor having one end adapted to be electrically connected to said source of voltage and having the other end electrically connected to the second end of said input winding,

a transistor having its collector electrically connected to the other end of said inductor and to the second end of said input winding, having its emitter grounded, and having its base adapted to receive a first signal for conducting current in one direction through said input winding and a second signal for conducting current in a direction through said input winding opposite to said one direction,

a first diode and a second diode series connected with the anode of said first diode electrically connected to the first end of said input winding, and

the cathode of said first diode being connected to the anode of said second diode, and the cathode of said second diode grounded.

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JOHN S. HEYMAN, Primary Examiner

U.S. Cl. X.R.

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