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Pugh

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[54] **DRIVER CIRCUITRY**

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[52] **U.S. Cl.** ....**317/137,** 317/DIG. 4, 317/148.5 R

[51] **Int. Cl.** **H01f 7/18**

[58] **Field of Search** 317/DIG. 4, 7, 137; 340/176

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[57] **ABSTRACT**

A clutch or similar device electronic driver circuit whereby the clutch coil is connected in series with a variable resistance circuit, such as a parallel connected diode and resistor, which displays a first resistance when current flows through the serial combination in a first direction to actuate the clutch and a second greater resistance when current flows through the serial combination in an opposite direction to produce a small reverse bias voltage across the coil which serves to demagnetize it and thus increase the speed of response of the coil as it is deactuated. Two electronic switching circuits are connected to the load for reversing the polarity of the voltage across the load and accordingly actuate and demagnetize the clutch alternately in response to input signals. A high transient current is produced at the time the coil is activated to ensure a quick response from the clutch. In the embodiment set forth below, the load comprises two alternately connected coils each having a variable resistance connected in series with it so that one coil is actuated while the other is being demagnetized and vice versa.

10 Claims, 3 Drawing Figures

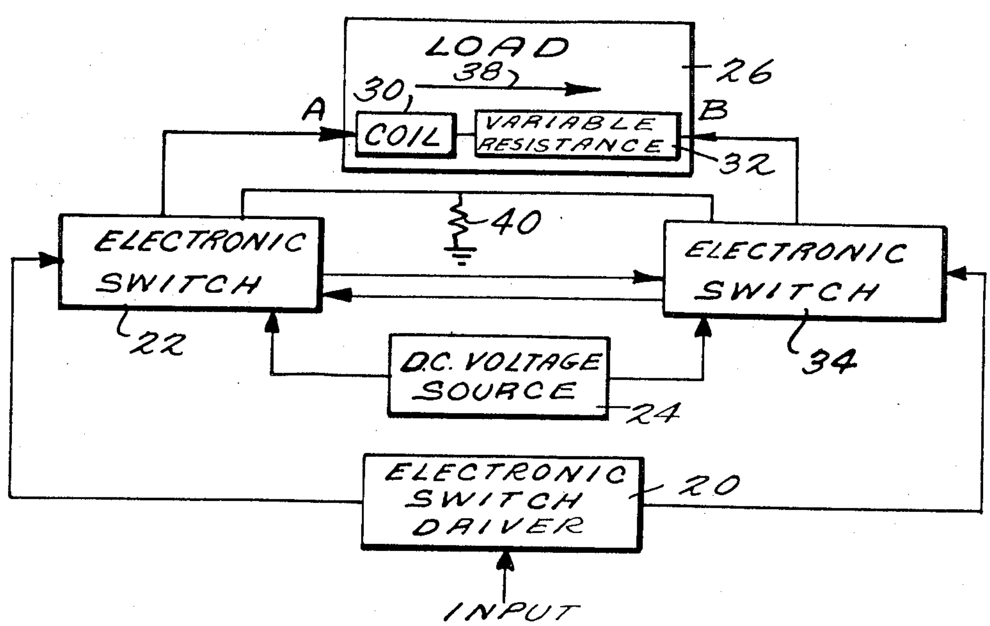

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Fig. 1.

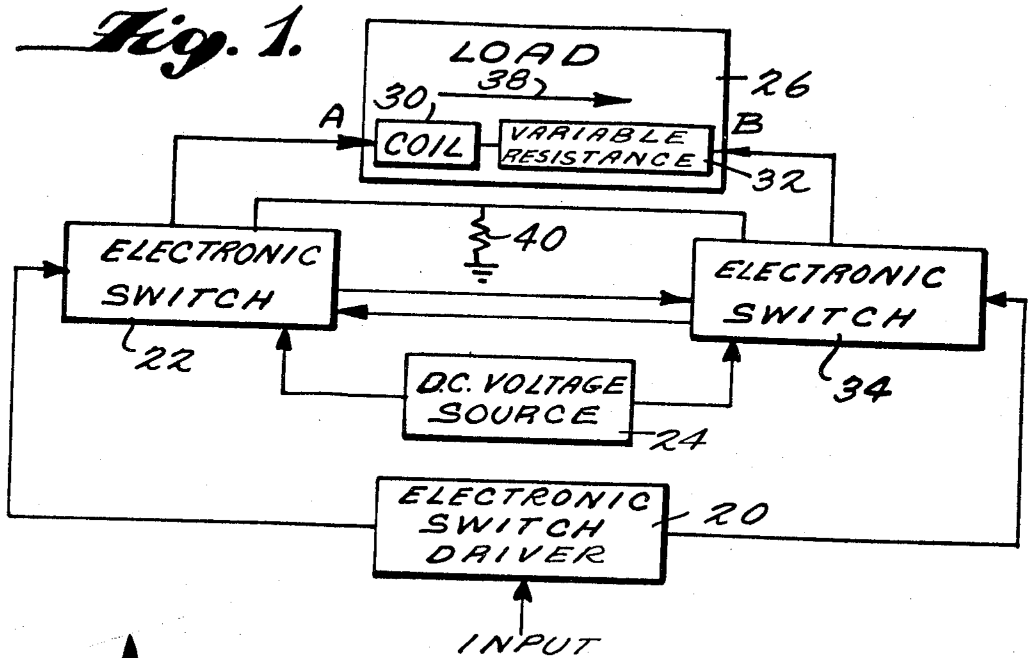
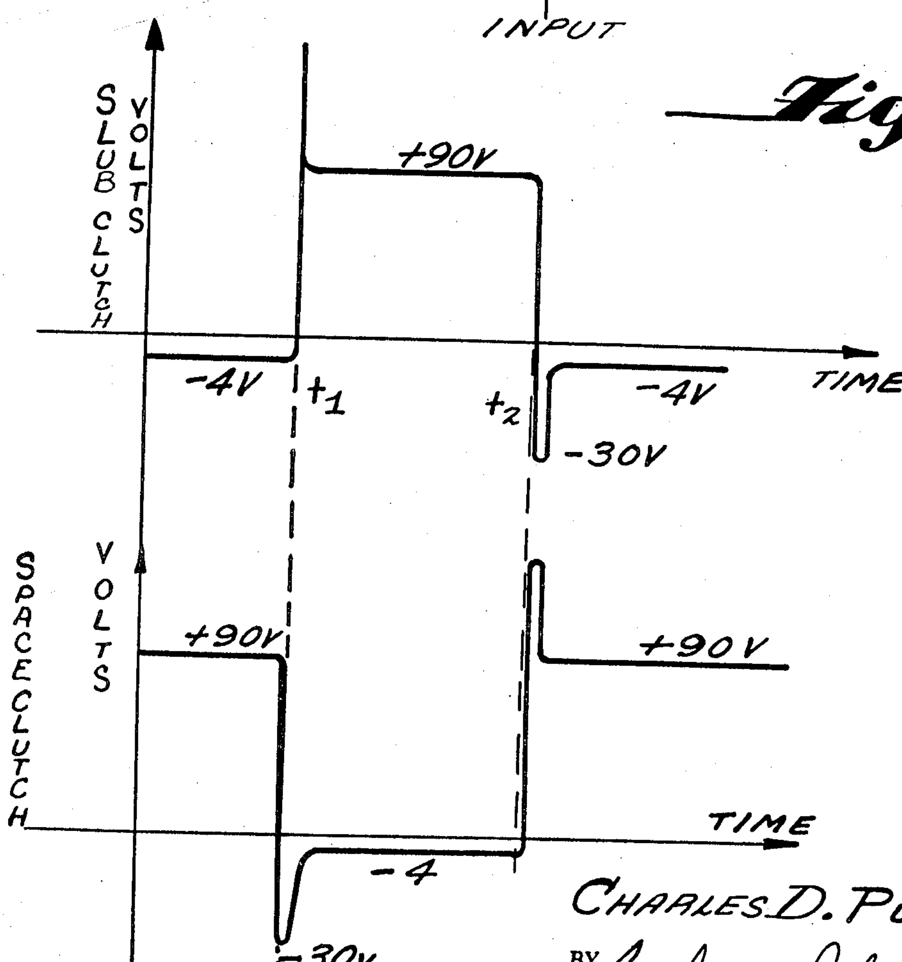


Fig. 3.



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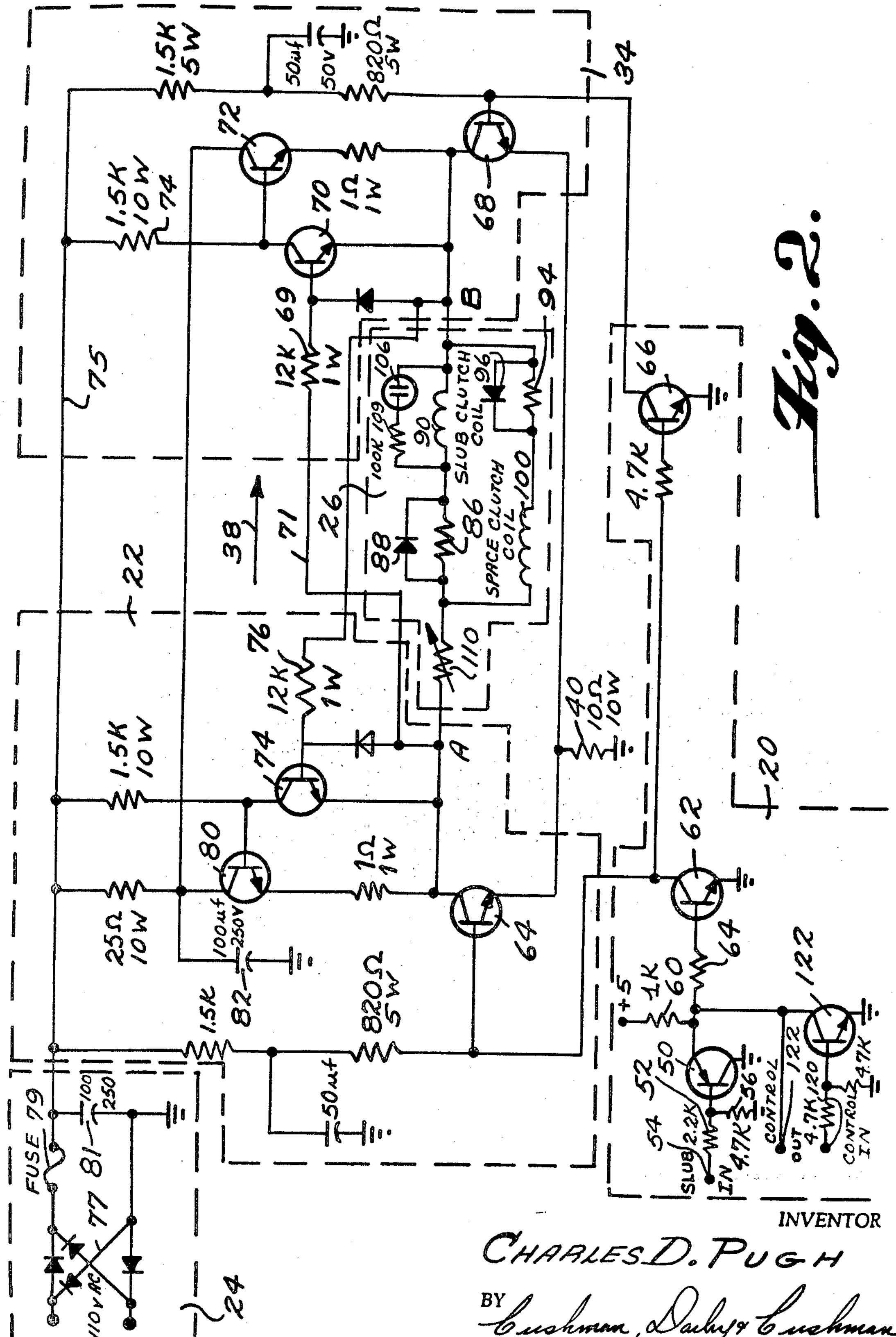

Fig. 2

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DRIVER CIRCUITRY

BRIEF DESCRIPTION OF THE PRIOR ART AND SUMMARY OF THE INVENTION

The invention relates to a driver circuit for a clutch or similar device.

Electric clutches, brakes, solenoids and similar devices operate by storing energy which flows in the form of an electric current through a coil and using that energy to perform a mechanical function. As a result of that storage, the coil becomes magnetized while the clutch remains actuated and normally retains and builds up a residual magnetism after current ceases flowing through it and the clutch is deactuated. This residual magnetism can build up to a level where it considerably reduces the time it takes for the clutch, brake, solenoid, etc. to become deactuated after current ceases flowing through it.

A further problem with such devices is that the instantaneous current required to energize or collapse the magnetic field is much greater than the normal operating current required. These transient currents tend to burn, pit and in general deteriorate conventional electrical contacts, when such contacts are used to interrupt and complete the current path through the load. Such deterioration is magnified where the switching speed is rapid and, indeed, the physical speed with which the contacts can be opened and closed severely limits the speed with which the clutch, coil or brake can be alternately actuated and deactuated.

The present invention relates to a novel driver circuitry whereby a small reverse bias voltage is provided across the coil while it is deactuated so that the coil is demagnetized. This is accomplished in the embodiment of the invention set forth below by providing a variable resistance circuit in series with the coil so that the serial combination comprises a load. The resistance circuit, which is preferably a resistor connected in parallel with a diode, displays a first resistance when current flows through the combination in a first direction so that the diode shunts the resistor and the coil is actuated and a second resistance when current flows through the combination in an opposite direction such that the diode is turned off and a small reverse bias voltage sufficient for demagnetization is provided across the coil.

According to the embodiment of the invention set forth below, this current reversal is preferably accomplished by electronic circuitry which can actuate and deactuate the coil much quicker than any mechanical contacts, and can safely switch comparatively large amounts of power with relatively small expenditures of power. Two electronic switches are connected to each other, to an input driver circuit, to a D.C. power supply and each to one side of the load. When the input driver circuit receives a first signal, one of the electronic switches applies a low voltage to the side of the load to which it is connected while the other electronic switch applies a high voltage to the side of the load to which it is connected. When, thereafter, the input driver circuit receives a second signal the polarity of the voltage across the load is reversed. Whenever current flows through a coil to actuate it, a transient voltage is produced across the coil which causes it to be quickly actuated and, in the case of a clutch, to securely and quickly grab.

Many of the objects and purposes of the invention will become clear from the following detailed description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of one embodiment of this invention.

FIG. 2 shows a detailed schematic of the embodiment of FIG. 1.

FIG. 3 shows a plot of the voltages across the coils in the schematic of FIG. 2.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIG. 1 which shows a block diagram of one embodiment of the novel driver circuitry of this invention. As mentioned above, this circuit includes an electronic switch driver **20**, which is adapted for receiving at least first and second input signals, either on separate lines or on the same line. When the first input signal is received, the driver circuitry produces a suitable signal which is received by electronic switch **22**, connected to driver **20** as shown, so that switch **22** applies at least a substantial portion of the voltage of a conventional D.C. voltage source **24**, developing, for example, 150 volts D.C., to terminal A of load **26**, which is preferably comprised of at least one coil **30** of an electric clutch, a solenoid or other similar device through which current flows to generate a magnetic field and store energy which is then used to accomplish a mechanical function. Coil **30** is connected in series with a variable resistor **32**, which exhibits one resistance when current flows through it in a first direction and a different resistance when the current flows through it in the opposite direction.

Electronic switch **22** is connected to a second electronic switch **34**, as is switch driver **20**, so that when switch **22** applies a substantial portion of the voltage provided by source **24** to terminal A in response to the first input signal received by switch driver **20**, electronic switch **34** applies a voltage to terminal B which is lower than the voltage applied to terminal A so that current flows through the load **26** in the direction indicated by arrow **38**. Electronic switch **34** as well as electronic switch **22** is connected to ground via resistor **40** so that the voltage which switch **34** connects to terminal B, when switch driver **20** receives the first input signal, may be produced by directly connecting resistor **40** to terminal B.

Because of the substantial inductance which normally is inherent in coil **30**, the transient current through load **26** in the direction of arrow **38** at the time that switching occurs is substantial and produces a sharp voltage pulse across coil **30** which quickly generates the magnetic field and stores sufficient energy so that the mechanical function is accomplished quickly. In embodiments where the coil **30** is associated with a clutch this transient pulse operates to quickly grab the clutch. Operation in this fashion has been found to greatly improve the lifetime and reliability of the clutch in contrast to most arrangements in which it is not applied so abruptly.

The current flow through coil **30** in the direction shown by arrow **38** continues with the voltage across coil **30** during the steady state period being sufficient to perform the mechanical function desired. Thereafter, when the second input signal is applied to electronic switch driver **20**, a signal is produced and applied by driver **20** to electronic switch **34** which causes switch **34** to apply a voltage to terminal B which is a substantial portion of the voltage provided by source **24**, and at the same time causes switch **22** to apply a voltage to terminal A which is substantially less than the voltage applied to terminal B, so that the polarity across load **26** is reversed and current begins to flow through load **26** in a direction opposite that shown by arrow **38**.

However, as mentioned above, variable resistor **32** is designed to display a high resistance when current is flowing in a direction opposite to that represented by arrow **38**, and to display a low resistance when current is flowing in the direction of arrow **38**. However, sufficient reverse current does flow through load **26** and coil **30** to apply a small reverse bias voltage across coil **30** which operates to demagnetize the coil. As mentioned above, this demagnetization occurs each time that the current is reversed so that the delay in causing deactuating a magnetized coil after current ceases flowing through it is eliminated.

Reference is now made to FIG. **2** which shows a detailed schematic of one circuit for carrying out the functions of the circuitry shown in block diagram shown in FIG. **1** and to FIG. **3** which shows the voltage across the two coils operated by the circuitry of FIG. **2**. In this arrangement, driver circuitry **20** includes a transistor **50** which has its base connected via resistor **52** to slub in terminal **54**. The base of transistor **50** is also connected to ground via resistor **56**. Thus, when the slub in terminal **54** is essentially at ground so that transistor **50** is turned on and driven into the saturated region by the voltage existing between the base and the emitter thereof, as applied by resistor **60**, saturated transistor **50** applies a low voltage, essentially at ground, to the base of transistor **62** via resistor **64** so that transistor **62** is kept in a non-conductive condition. Because transistor **62** is non-conductive, a high voltage is applied to the bases of transistors **64** and **66** so that these transistors are driven deep into their saturation regions, and accordingly ground is effectively applied to the collector of transistor **64** via resistor **40** and to the collector of transistor **66**. Since the collector of transistor **66** is essentially at ground, transistor **68** is maintained in its non-conductive state. Further, the collector of transistor **64** is connected to the base of transistor **70** via resistor **69** and line **71**, so that transistor **64** applies an input of essentially ground to the base of transistor **70** which keeps transistor **70** in its non-conductive condition. The base of transistor **72** is connected to the collector of transistor **70** which is connected to power supply line **75** by resistance **74**, so that when transistor **70** is non-conductive and transistor **68** is non-conductive, transistor **72** is conductive and applies a high voltage to terminal B of load **26**. Power line **75** connects, as shown, to conventional D.C. power supply **24** which inclues full wave rectifying diodes **77**, fuse **79** and smoothing capacitor **81**.

The base of transistor **74** is similarly connected to terminal B via resistor **76** such that when terminal B is at the high voltage and transistor **64** is in its conductive condition, a voltage is applied between the base and emitter of transistor **74** which drives that transistor into its saturation region, thus essentially grounding the base of transistor **80** via resistor **40** so that transistor **80** remains in its non-conductive condition. In this fashion, a voltage of a first polarity is established between terminals A and B so that current flows through the load in a direction opposite to that indicated by arrow **38**. A capacitance **82** is connected to the collectors of transistors **72** and **80** for preventing the voltage at that point from collapsing too rapidly when the electronic switches which include these transistors shift from their first to second output conditions to reverse the polarity of the voltage across load **26** and the direction of current flow through that load.

When terminal B is at a higher voltage than terminal A as described above, current flows in a direction opposite to that indicated by arrow **38** through load **26** and, more particularly, through a first circuit comprised of parallel connected resistor **86** and diode **88**, which are connected in series with a slub clutch coil **90**, and through a second circuit comprised of a further parallel connected resistor **94** and diode **96**, which are connected in series as shown with a space clutch coil **100**. Resistor **86** and diode **88** in effect form a variable resistance element which has a relatively low resistance as current flows through load **26** in the direction of arrow **38** and diode **88** shunts resistor **86**. Conversely when current flows through resistor **86**, diode **88** and slub clutch coil **90** in a direction opposite to that indicated by arrow **38**, no current flows through diode **88**, which is biased in its non-conductive condition and the resistance presented by the parallel connected resistor **86** and diode **88** is substantial. Thus, when current flows through load **26** in the direction indicated by an arrow **38**, the voltage drop across slub clutch coil **90**, as shown in FIG. **3**, is essentially the voltage drop across the terminals A and B of load **26**, and when current flows in the opposite direction, the voltage drop across the slub clutch coil **90** is a small portion thereof and is of an opposite polarity.

The circuit is connected such that when current flows in the direction of arrow **38** and the voltage across slub clutch coil **90** is essentially the voltage between terminals A and B of load **26**, the energy which the coil stores is sufficient to perform the mechanical function of the coil. When current flows in the opposite direction, the voltage across slub clutch coil **90** is just sufficient to de-magnetize that coil, as discussed above. A resistor **104** and neon light **106** are connected in parallel with the slub clutch coil **90** in order to indicate when slub clutch coil **90** is in operation.

Similarly, a second coil **100**, termed the space clutch coil, is connected in series with resistance **94** and diode **96** as shown, such that when the voltage at terminal B exceeds the voltage at terminal A, the parallel connected resistor **94** and diode **96** present a relatively low resistance because diode **96** essentially shunts resistor **94** so that the voltage across space clutch coil **100** is essentially the voltage between terminals A and B, and the clutch associated with coil **100** is actuated to perform its mechanical function. Similarly, when current flows through load **26** in the direction of arrow **38** and the voltage at terminal A is greater than the voltage at terminal B, the resistance presented by the parallel connected resistor **94** and diode **96** is substantial, such that a small residual voltage across coil **100** results which is of an opposite polarity and which is sufficient to de-magnetize the coil. In the particular configuration shown in FIG. **2**, the two coils **90** and **100** are actuated and de-magnetized alternately with one coil being de-magnetized while the other coil is actuated. This particular arrangement has been found to be particularly advantageous for actuating the clutches termed the space and slub clutches which are employed in producing slub yarn. Further, details of one such device are set forth in a Pugh application filed herewith entitled "Control Mechanism for Producing Random-Like Effects on Textile Materials" and the disclosure of that application is explicitly incorporated herein by reference. A variable resistor **110** is connected in series with load **26** for varying the current flow through the load to any desired level.

When a second signal is supplied to slub in terminal **54** which is high with respect to ground, transistor **50** is driven into its non-conductive region, thus causing a high voltage to be applied to the base of transistor **62** which becomes conductive, applying ground to the base of transistor **66** and to the base of transistor **64.** Both of these transistors are thus driven into their non-conductive states. The shifting of transistor **66** from its conductive to its non-conductive condition applies a high input to the base of transistor **68** whose emitter is connected to ground by resistor **40** so that transistor **68** shifts to its conductive condition applying a low voltage essentially at ground to terminal B. The voltage at terminal B is applied to the base of transistor **74** via resistor **76** so that transistor **74** is similarly driven into its non-conductive region, permitting transistor **80** to become conductive and applying a high voltage to terminal A.

Similarly, a high voltage is now applied to the base of transistor **70** via line **71** and resistor **69** such that transistor **70** is driven into its conductive region, in turn causing transistor **72** to become non-conductive. The current now flows through load **26** from terminal A to terminal B via transistor **80,** transistor **68** and resistor **40.** Thus the current applied across the terminals A and B is the same in each instance; only the polarity of the voltage across load **26** has been changed.

Control in terminals **120** and **122** can be employed to hold the circuit in either of its output conditions irregardless of the input applied to terminal **54.** If a high input is applied to terminal **122,** that input remains as the input to the base of transistor **62** regardless of whether or not transistor **50** thereafter is driven into its conductive region in response to a low input on slub in terminal **54.** Similarly, when a high input is applied to control in terminal **120,** transistor **122** is driven into its conductive condition and applies a voltage of essentially ground to the input of transistor **62** so that transistor remains in a non-conductive condition.

As mentioned above, while this particular circuit has been found to be especially advantageous in controlling the operation of clutches which are employed in making slub yarn, such circuitry can be employed in a wide variety of application for controlling any of a number of different devices such as clutches, brakes, etc. in which current through a coil or the like is employed to store energy in a magnetic field and use that energy to perform a mechanical function. For example, the circuit has also been found to be particularly successful in operating the feed circuit on a drapery cutting table where the circuit is actuated by a push button to operate an electric clutch with the clutch delivering a specified length of cloth to the cutting table. Once the specified length was reached, the circuit is switched by a photocell unit to relieve the clutch and act as a brake. The fast switching characteristics of the circuit shown in FIG. **2** has been found to substantially improve the accuracy of control as compared to conventional relay type switches previously used on cutting table controls.

This circuit has been found to provide very fast switching as compared to well known microswitch and relay switching characteristics, both because of the relatively high transient voltage which is applied across the coil to actuate it, and the small reversible polarity voltage which is applied across the coil, when the circuit is not in operation, to de-magnetize it. It has been found that this circuit provides an impulse voltage up to 150 percent of the operating voltage in switching brakes, clutches and solenoid, and this permits increased speed in magnetic field build-up and increases speed in operation of the device. This circuit, of course, has no moving parts and has been found to be capable of dissipating switching power troubles caused by stored energy without any harm to the circuit.

In the specific circuit of FIG. **2,** representative values are given for each of the elements but no limitation to these values is intended.

What is claimed is:

1. A driver circuit for operating devices of the type in which electrical current flows through a portion thereof so that electrical energy is stored for accomplishing a mechanical function when the stored energy exceeds a given level comprising:

circuit means, connected in series with said portion, having a first resistance value when a given voltage across said serially connected circuit means and portion is a first polarity so that current flows through said serially connected circuit means and portion in a first direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when a given voltage across said serially connected circuit means and portion is the opposite polarity so that significant, but less current flows through said serially connected circuit means and portion in an opposite direction and so that said current flowing in said opposite direction will not cause sufficient energy to be stored to accomplish a function but will establish a significant voltage across said portion, and

means connected to said circuit means and portion for providing said given voltage of said first polarity across said serially connected portion and circuit means, when a first input signal is received, so as to produce a voltage of said first polarity across said portion and magnetization of said portion and for providing said given voltage of said opposite polarity across said serially connected circuit means and portion when a second input signal is received so as to produce a smaller voltage of the opposite polarity across said portion causing smaller but significant current flow through said portion so that said portion is demagnetized.

2. A driver circuit as in claim **1** wherein said circuit means is a resistor and a diode connected in parallel with said resistor so that said diode conducts current when said given voltage of said first polarity is applied to said serially connected circuit means and portion and does not conduct current when said given voltage of said opposite polarity is applied to said serially connected circuit means and portion.

3. A driver circuit as in claim 1 wherein said device is a clutch and said portion is a coil and including said coil.

4. A circuit as in claim 1 further including second circuit means connected in series with another portion of another device, said serially connected second circuit means and another portion being connected in parallel with said serially connected first circuit means and portion and said second circuit means having a first resistance value when said given voltage across said serially connected second circuit means and another portion is said second polarity so that current flows through said serially connected second circuit means and another portion in said opposite direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when said given voltage across said serially connected second circuit means and another portion is said first polarity so that current flows through said serially connected second circuit means and another portion in said first direction and so that said current flowing in said first direction will not cause sufficient energy to be stored to accomplish said function, and wherein said providing means provides said given voltage of said first polarity across said serially connected another portion and second circuit means, when said first input signal is received so as to produce a voltage of said first polarity across said another portion so that said another portion is demagnetized and provides said given voltage of said opposite polarity across said serially connected second circuit means and another portion when said second input signal is received so as to produce a larger voltage of the opposite polarity across said portion so that said portion is magnetized.

5. A circuit as in claim 1 wherein said providing means includes means for providing a DC voltage, first electronic switch means having a first condition connecting at least a portion of said DC voltage to one side of said serially connected circuit means and portion and a second condition connecting a lower voltage to said one side, second electronic switch means having a first condition connecting at least a portion of said DC voltage to the other side of said serially connected circuit means and portion and a second condition connecting a lower voltage to said other side, and third electronic switch means connected to said first and second electronic switch means for receiving said first and second input signals, causing said first switch means to shift from its first to its second condition and said second switch means to shift from its second to its first condition when said first input signal is received and causing said first switch means to shift from its second to its first condition and said second switch means to shift from its first to its second condition when said second input signal is received.

6. A circuit as in claim 5 further including a variable resister serially connected to said serially connected portion and circuit means.

7. A circuit as in claim 5 wherein said electronic switch means each includes at least a single transistor.

8. A driver circuit for operating first and second clutches in which electrical current flows through a coil thereof so that electrical energy is stored for accomplishing a mechanical clutch function when the stored energy exceeds a given level comprising:

first circuit means, connected in series with said coil of said first clutch, having a first resistance value when a given voltage across said serially connected circuit means and first clutch coil is a first polarity so that current flows through said serially connected circuit means and first clutch coil in a first direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when a given voltage across said serially connected circuit means and first clutch coil is the opposite polarity so that significant but less current flows through said serially connected circuit means and first clutch coil in an opposite direction and so that said current flowing in said opposite direction will not cause sufficient energy to be stored to accomplish a function but will establish a significant voltage across said first clutch coil,

means connected to said circuit means and first clutch coil for providing said given voltage of said first polarity across said serially connected first clutch and circuit means, when a first input signal is received, so as to produce a voltage of said first polarity across said first clutch coil and magnetization of said first clutch coil and for providing said given voltage of said opposite polarity across said serially connected circuit means and first clutch coil when a second input signal is received so as to produce a smaller voltage of the opposite polarity across said first clutch coil causing smaller but significant current flow through said first clutch coil so that said first clutch coil is demagnetized, and

second circuit means connected in series with said second clutch coil, said serially connected second circuit means and second clutch coil being connected in parallel with said serially connected first circuit means and first clutch coil and said second circuit means having a first resistance value when said given voltage across said serially connected second circuit means and second clutch coil is said second polarity so that current flows through said serially connected second circuit means and second clutch coil in said opposite direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when said given voltage across said serially connected second circuit means and second clutch coil is said first polarity so that current flows through said serially connected second circuit means and second clutch coil in said first direction and so that said current flowing in said first direction will not cause sufficient energy to be stored to accomplish said function, and wherein said providing means provides said given voltage of said first polarity across said serially connected second clutch coil and second circuit means, when said first input signal is received so as to produce a voltage of said first polarity across said second clutch coil so that said second clutch coil is demagnetized and provides said given voltage of said opposite polarity across said serially connected second circuit means and second clutch coil when said second input signal is received so as to produce a larger voltage of the opposite polarity across said first clutch coil so that said first clutch coil is magnetized.

9. A driver circuit for operating devices of the type in which electrical current flows through a portion thereof so that electrical energy is stored for accomplishing a mechanical function when the stored energy exceeds a given level comprising:

first circuit means, connected in series with said portion, having a first resistance value when a given voltage across said serially connected circuit means and portion is a first polarity so that current flows through said serially connected circuit means and portion in a first direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when a given voltage across said serially connected circuit means and portion is the opposite polarity so that significant but less current flows through said serially connected circuit means and portion in an opposite direction and so that said current flowing in said opposite direction will not cause sufficient energy to be stored to accomplish a function but will establish a significant voltage across said portion said circuit means including a resistor and a diode connected in parallel with said resistor so that said diode conducts current when said given voltage of said first polarity is applied to said serially connected circuit means and portion and does not conduct current when said given voltage of said opposite polarity is applied to said serially connected circuit means and portion,

means connected to said circuit means and portion for providing said given voltage of said first polarity across said serially connected portion and circuit means, when a first input signal is received, so as to produce a voltage of said first polarity across said portion and magnetization of said portion and for providing said given voltage of said opposite polarity across said serially connected circuit means and portion when a second input signal is received so as to produce a smaller voltage of the opposite polarity across said portion causing smaller but significant current flow through said portion so that said portion is demagnetized and

second circuit means connected in series with another portion of another device, said serially connected second circuit means and another portion being connected in parallel with said serially connected first circuit means and portion and said second circuit means having a first resistance value when said given voltage across said serially connected second circuit means and another portion is said second polarity so that current flows through said serially connected second circuit means and another portion in said opposite direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance valve when said given voltage across said serially connected second circuit means and another portion is said first polarity so that current flows through said serially connected second circuit means and another portion in said first direction and so that said current flowing in said first direction will not cause sufficient energy to be stored to accomplish said function, and wherein said providing means provides said given voltage of said first polarity across said serially connected another portion and second circuit means, when said first input signal is received so as to produce a voltage of said first polarity across said another portion so that said another portion is demagnetized and provides said given voltage of said opposite polarity across said serially connected second circuit means and another portion when said second input signal is received so as to produce a larger voltage of the opposite polarity across said portion so that said portion is magnetized said second circuit means including a second resistor and a second diode connected in parallel with said second resistor so that said second diode conducts current when said given voltage of said first polarity is applied to said serially connected second circuit means and another portion and does not conduct current when said given voltage of said opposite polarity is applied to said serially connected second circuit means and another portion.

10. A driver circuit for operating devices of the type in which electrical current flows through a portion thereof so that electrical energy is stored for accomplishing a mechanical function when the stored energy exceeds a given level comprising:

first circuit means, connected in series with said portion, having a first resistance value when a given voltage across said serially connected circuit means and portion is a first polarity so that current flows through said serially connected circuit means and portion in a first direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when a given voltage across said serially connected circuit means and portion is the opposite polarity so that significant, but less current flows through said serially connected circuit means and portion in an opposite direction and so that said current flowing in said opposite direction will not cause sufficient energy to be stored to accomplish a function but will establish a significant voltage across said portion,

means connected to said circuit means and portion for providing said given voltage of said first polarity across said serially connected portion and circuit means, when a first input signal is received, so as to produce a voltage of said first polarity across said portion and magnetization of said portion and for providing said given voltage of said opposite polarity across said serially connected circuit means and portion when a second input signal is received so as to produce a smaller voltage of the opposite polarity across said portion causing smaller but significant current flow through said portion so that said portion is demagnetized,

second circuit means connected in series with another portion of another device, said serially connected second circuit means and another portion being connected in parallel with said serially connected first circuit means and portion and said second circuit means having a first resistance value when said given voltage across said serially connected second circuit means and another portion is said second polarity so that current flows through said serially connected second circuit means and another portion in said opposite direction and so that said current flowing in said first direction is sufficient to store sufficient energy to accomplish said function and having a second and greater resistance value when said given voltage across said serially connected second circuit means and another portion is said first polarity so that current flows through said serially connected second circuit means and another portion in said first direction and so that said current flowing in said first direction will not cause sufficient energy to be stored to accomplish said function, and wherein said providing means provides said given voltage of said first polarity across said serially connected another portion and second circuit means, when said first input signal is received so as to produce a voltage of said first polarity across said another portion so that said another portion is demagnetized and provides said given voltage of said opposite polarity across said serially connected second circuit means and another portion when said second input signal is received so as to produce a larger voltage of the opposite polarity across said portion so that said portion is magnetized,

said providing means including means for providing a DC voltage, first electronic switch means having a first condition connecting at least a portion of said DC voltage to one side of said serially connected circuit means and portion and a second condition connecting a lower voltage to said one side, second electronic switch means having a first condition connecting at least a portion of said DC voltage to the other side of said serially connected circuit means and portion and a second condition connecting a lower voltage to said other side, and third electronic switch means connected to said first and second electronic switch means for receiving said first and second input signals, causing said first switch means to shift from its first to its second condition and said second switch means to shift from its second to its first condition when said first input signal is received and causing said first switch means to shift from its second to its first condition and said second switch means to shift from its first to its second condition when said second input signal is received.

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