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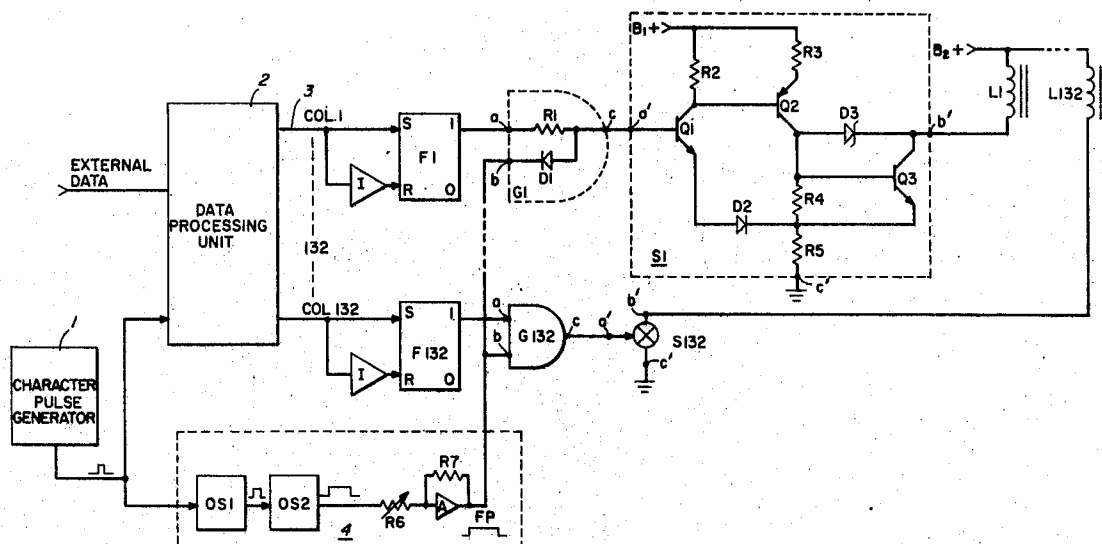
[54] **HAMMER DRIVING CIRCUITS FOR HIGH-SPEED PRINTERS**
15 Claims, 1 Drawing Fig.

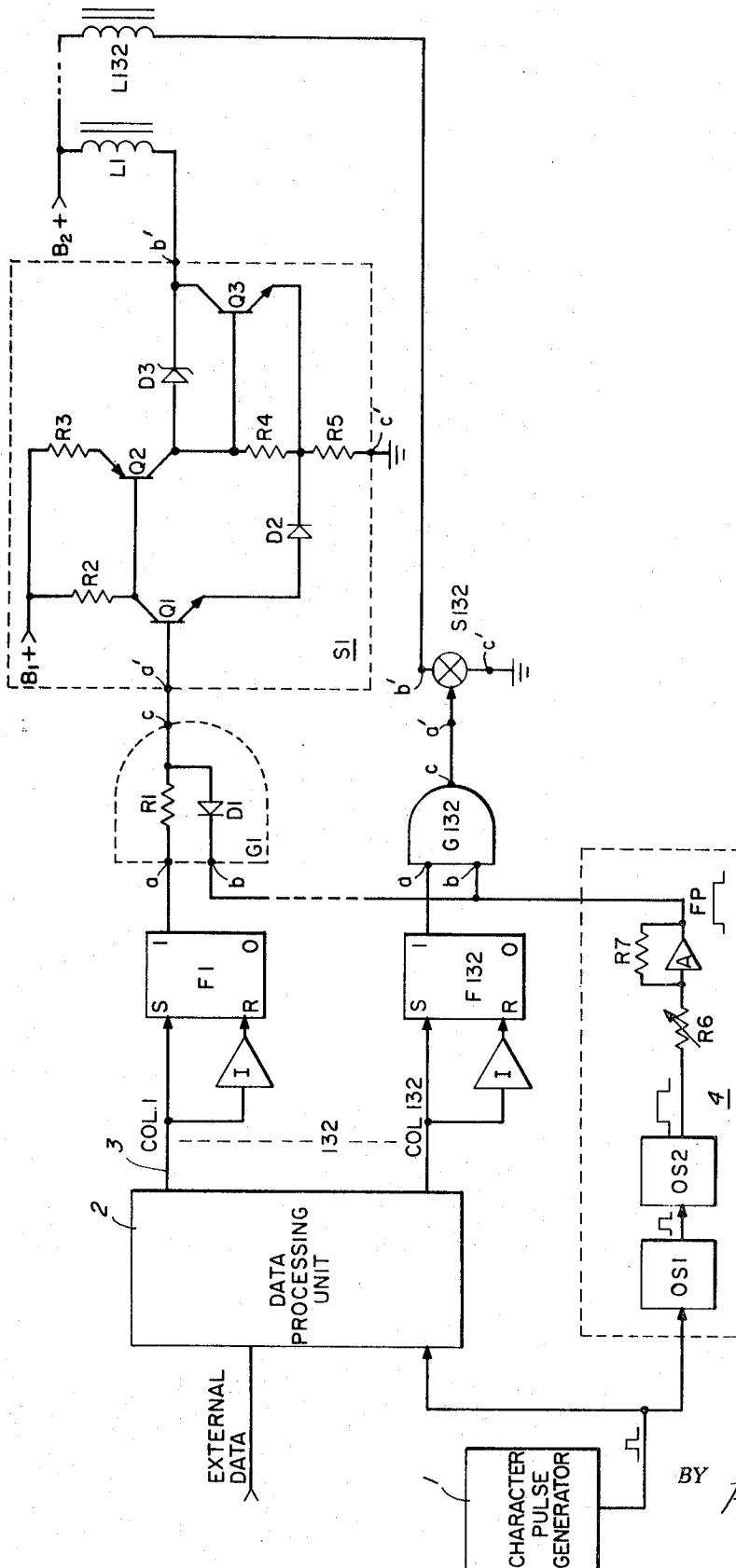
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DIG. 5, 137, 148.5, 155.5, 157; 307/218, 221;
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3,293,505 12/1966 Miller **317/DIG. 4**
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ABSTRACT: Control circuits for high-speed printers having solenoid actuated hammers, in which for each hammer the solenoid is connected through a current-control switch to a source of current, for each switch there is an AND gate having two input terminals, one being a voltage tolerant terminal connected to a register for a logic signal indicating when the hammer is to be fired, and the other being a control terminal connected to a common terminal for all of the gates that is adapted to be connected to a control pulse generator of precise level and duration.





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HAMMER DRIVING CIRCUITS FOR HIGH-SPEED PRINTERS

My invention relates to high-speed printers, and particularly to a novel hammer actuating circuit for controlling the actuation of the hammers of a high-speed printer.

A basic problem is constructing a high-speed impact printer of the line at a time type is to provide over the energization of the hammers so that they are fired at precisely the right position of the print carrier and with reproducibly metered amounts of energy so that straight lines of uniform quality are produced.

Two basically different approaches have previously been taken to the solution of this problem. A first approach involves the use of a bank of capacitors, one for each hammer driver solenoid, and each connected in series with its associated solenoid through an electronic switch of the avalanche type, such as a silicon controlled rectifier or the like. In the intended mode of operation, the capacitors are all charged to suggested constant, precise voltage, so that each will deliver the same pulse of current to its associated hammer driver when the switch is turned on. The problem is that great demands are placed on the power supply, because the number of capacitors that have to be charged at any given time depends upon the number of hammers that have been actuated. On a 100-column printer, for example, that number can vary from none to 100. Cumbersome, complex and costly power supplies are required to produce a suitably fixed charge on the capacitors under these varying conditions of operation.

Another approach, also placing onerous requirements on the power supply, involves timing the application of constant current to the solenoid by means of an electronic switch supplied with a timing pulse of precise duration for metering the current supplied to each hammer driving solenoid during the time the associated switch is closed. In addition to requiring a precision power supply that will produce an accurate voltage under widely varying conditions of load, as previously implemented, that approach has required large numbers of precision timing circuits. The object of my invention is to facilitate the precise control of print hammer driving circuits, while reducing the requirements of the power supply.

Briefly, the above and other objects of my invention are attained by means of a novel print hammer control circuit in which a single precision pulse generator is employed that produces a pulse of predetermined magnitude and duration to govern both the time interval during which the hammer driving solenoids are energized, and the amount of current that will be supplied to each solenoid that is energized. This pulse generator is connected to one input terminal of a series of specially constructed AND gates, one for each hammer driver solenoid. Each AND gate has one input terminal that is relatively insensitive to applied voltage level, and a second input terminal that is sensitive to the applied voltage level. The precision pulse generator pulse is applied to the sensitive input terminal of each gate circuit. The voltage tolerant input terminal of each gate is connected to a register for the associated print hammer that stores a signal indicating whether or not the hammer is to be fired. The register circuits may be integrated circuits, which are characterized by the production of logic levels that are relatively imprecise. Thus, for example, such a register might produce a logic zero at ground level, and a logic one that might be any level from 3 to 5 volts positive. Each gate circuit serves to perform the logical AND function on signals applied to the input terminals, and to produce either a regulated logic one level directing the hammer to be fired at a voltage determined solely by the level of the precision timing pulse, or a logic zero level during the interval of the precision timing pulse, in dependence upon whether or not the associated register stores a logic one or a logic zero. The output of each gate controls a current control switch connected in series with the associated hammer driver solenoid. Each current control switch allows a current flow through its associated hammer driver solenoid with a magnitude depending on the amplitude of the signal applied to the current control switch, and for a time determined by the time during which the signal

is applied to the switch. As will appear, the current control switch is so constructed that the requirements on the power supply are considerably less onerous than those commonly encountered in prior constructions.

The manner in which the apparatus of my invention is constructed, and its mode of operation, will best be understood in the light of the following detailed description, together with the accompanying drawing, of a preferred embodiment of my invention.

In the drawing, the sole FIGURE comprises a block and wiring diagram of a print hammer actuating circuit in accordance with my invention.

While the apparatus of my invention can be used with any high-speed printer of the type in which any, some or all of the image forming elements may be required to be energized at the same time, for clarity of illustration it will be described as forming a part of a conventional impact drum printer. Such a printer has a print drum on which there are engraved parallel rows of characters; for example, 64 rows of different alpha-numeric characters. The print drum rotates at constant speed with respect to a straight line of hammers. Thus, for a 132-column printer, there would be 132 hammers and 132 columns of 64 characters engraved on the print wheel, the 64 characters of each column passing successively past the associated hammer. Each like character of the several columns would be in a line parallel to the axis of the print roll, such that, for example, all of the A's would come into printing position at the same time. Such a printer is conventionally provided with a character pulse generator, indicated schematically at 1 in the drawing, which produces an output pulse as each row of like characters comes into position, and controls the timing of the printing operation. Thus, for a 64-character printer, there would be 64 character pulses produced for each revolution of the print roll. Character pulses CP, thus produced, are used to control a conventional data processing unit schematically indicated at 2 and also to control a precision-timing generator, to be described.

The data processing unit 2 may be of any conventional construction including a line memory adapted to accept external data from a computer or the like, in the form of signals indicating the characters to be printed in a line of print. Each character pulse CP functions in a conventional manner to initiate a scan of the memory in composition with a comparator in the data processing unit to produce a "true compare" signal for each column in which the character associated with that character pulse is to be printed. For example, the character pulses may be used to step a counter, the state of which identifies the character then coming in position, and which provides one input to the comparator. Following each character pulse CP, a search of the memory is made, and for each column in which the corresponding character is to be printed, a register is set.

In practice, I prefer to employ two sets of registers, as more fully disclosed in copending U.S. application, Ser. No. 70,222, filed at the same time as this application by John J. Foley for Print Control System for High Speed Printers, and assigned to the assignee of this application. That allows the first set of registers to accumulate the series of true compare signals for one character by scanning the memory, while the preceding set of true compare signals for the preceding character is stored in the second set of registers for printing. The scanning and printing operations can thus be overlapped, so that one scan of the memory and one character printout can occur after each character pulse except the first in any print cycle. In detail, following each character pulse, the contents of the first set of registers is entered into the registers of the second set, and the memory then scanned and compared with the incremented contents of the comparator while the first set of registers is loaded. However, the details of this apparatus and its mode of operation form no part of the invention here described and claimed, and only typical ones of the second set of registers are here shown and described.

Thus, for a 132-column printer, as the second set of registers there are provided 132 flip-flops, of which the first flip-flop F1 and the last flip-flop F132 are shown. Output signals from the data processing unit 2 are supplied to these registers F1 through F132 over lines such as 3 for column 1, which set or reset the flip-flops such as F1 means of a direct connection the the set terminal and a connection through an inverter I to the reset terminal of the flip-flop. The flip-flops such as F1 through F132 may be conventional flip-flops and formed as integrated circuits of the type which produce logic signal levels that may only approximate their nominal values. Thus, for clarity of exposition and as a particular example, it will be assumed that the level produces at the logic 1 terminal of the flip-flop F1 in the set state is a voltage that may be any value from 3 to 5 volts positive, and that the logic zero conditions are represented by approximately ground, or zero potential.

It should be noted that the manner in which the registers F1 through F132 are loaded is not essential to the practice of my invention, because that can be done in a number of conventional ways. The point is that, for the purposes of my invention, the logic levels produced by the registers need not be precise.

Following each character pulse CP by an interval sufficient to permit the data processing unit 2 to load the registers F1 through F132 is a precision timing and current control pulse FP. This pulse is produced by a precision-timing generator 4 in response to each character pulse CP. The construction of the precision pulse generator 4 is not critical, the significant point being that only one such pulse generator is required for the printer.

As schematically indicated, the pulse generator 4 may comprise a first one-shot multivibrator OS1, that produces a pulse of fixed duration starting at the trailing edge of the character pulse CP. The training edge of the pulse produces by the multivibrator OS1 is employed to trigger a second one-shot multivibrator OS2, to produce a delayed pulse of a second precise duration, such as 1.3 milliseconds for a 600 line per minute printer. An output pulse FP of the same duration of, for example, 1.3 milliseconds, and of precisely regulated voltage level, is produced by means here shown as an operational amplifier A having a feedback resistor R7 and an adjustable input resistor R6 with which the exact level of pulse FP can be controlled. The purpose of the operational amplifier is to compensate for loading effects dependent upon how many hammers are fired, as will appear.

An AND gate is provided for each column in the printer. As shown here, there is a gate G1 for column 1 and a gate G132 for column 132. Identical intermediate gates, not shown, are provided for the intervening columns 2 through 131.

Each gate such as G1 has a voltage kilogram input terminal *a* connected to the logic 1 output terminal of the corresponding flip-flop such as F1. Each gate such as G1 also has a voltage sensitive input terminal *b*, which is connected to the output of the precision pulse generator 4 to receive the pulses FP. Each of the gates such as G1 comprises a resistor R1 having one terminal connected to the input terminal *a* of the gate, and a second terminal connected to the output terminal *c* of the gate and to the anode of a diode D1. The cathode of the diode D1 is connected to the input terminal *b* of the gate.

In the discussion that follows, references will be made to forward drops through diodes and transistor junctions. For simplicity of exposition, it will be assumed that all such voltage drops are 0.5 volt. As will be apparent to those skilled in the art, the exact drops will depend on the transistor or diode types. Again for convenience, it will be assumed that the printer is arranged to operate at 600 lines per minute, so that there are about 1.56 milliseconds between character pulses CP. Under those conditions, the duration of the pulse FP may be 1.3 millisecond, and its level may be adjusted to +2.75 volts. When the pulse FP is absent, the output terminal of the pulse generator 4 will be assumed to be at ground potential.

With the values assumed, it will be apparent that the input terminal *a* of each gate such as G1 will be at either zero poten-

tial, or at a value between 3 and 5 volts, the latter depending upon the exact logic 1 output level produced by the registers such as F1. Input terminal *b* will be either at zero volts or at 2.75 volts. If the associated flip-flop such as F1 is in its reset state, with its logic 1 output terminal at ground potential, then the output terminal *c* of the gate such as G1 will be at ground potential approximately, regardless of the voltage at the input terminal *b* of the gate. When a flip-flop such as F1 is set, then the output terminal *c* of the associated gate such as G1 will be at plus 0.5 volt with respect to ground, if the input terminal *b* is at ground potential, or at +2.25 volts with respect to ground, if terminal *b* is at 2.75 volts. Variations of potential on the input terminal *a* of the gate G1 will not affect the potential at the output terminal *c* so long as the logic 1 voltage applied at terminal *a* is above the voltage at terminal *b* by at least the forward drop through the diode D1. Thus, the variations in logic voltage levels produced by typical integrated circuits can readily be accommodated.

The output terminal *c* of each of the gates G1 through G132 is connected to an input terminal *a* of a current control switch. The current control switch S1 is shown in detail, and corresponds to the current control switch for column 1. Each of the other switches, such as the switch schematically shown at S132 for column 132, may be of the same construction as the switch S1.

The input terminal *a* of the current control switch S1 is connected to the base of a conventional NPN-transistor Q1. The collector of the transistor Q1 is returned to suitable source of position potential B1 through a resistor R2. The emitter of the transistor Q1 is connected to ground through a diode D2 and a resistor R5 in series.

The collector of the transistor Q1 is connected to the base of a PNP-transistor Q2. The emitter of the transistor Q2 is returned to the positive terminal at the potential B1 through a resistor R3. The collector of the transistor Q2 is returned to ground through two resistors R4 and R5 in series.

The collector of the transistor Q2 is connected to the base of an NPN-power transistor Q3. The emitter of the transistor Q3 is connected to ground through the resistor R5. The collector of the transistor Q3 is connected to the output terminal *b* of the switch S1 and is also connected to the cathode of a zener diode D3. The anode of the diode D3 is connected to the collector of the transistor Q2.

The hammers of the printer are arranged to be actuated by an actuating solenoid for each hammer, such as the solenoids L1 through L132, of which the first and last are shown. The solenoid windings such as L1 may be wound in a conventional manner on a core, and arranged to attract an associated armature when energized. The armature may drive the hammer, either directly or through an intermediate actuating arm.

Each hammer actuated solenoid winding such as L1 has one terminal connected to a suitable source of regulated potential B2, which may be the same as, or different from, the potential B1. The source B2 should provide a constant potential within not more than pulse or minus 5 percent, regardless of the number of solenoids that are to be actuated at once. That requirement implies a reasonably good power supply, but not necessarily one that would meet the much high standards of conventional printer power supply circuits.

The second terminal of each hammer solenoid winding such as L1 is connected to the output terminal *b* of a corresponding current control switch, such as S1. When the power transistor such as Q3 in the switch S1 is biased against conduction, no current will flow through the corresponding coil such as L1. When the transistor Q3 is biased into conduction, current will flow from the positive terminal B2 through the winding L1, through the collector to emitter path of the transistor Q3, and through the resistor R5 to ground. As will appear, the impedance in the collector-emitter path of the transistor Q3 is so controlled that the current through the winding L1 is a constant value depending on the level of the voltage applied to the input terminal *a* of the switch S1.

The resistor R5 preferably has a small resistance, such as one-half ohm, and should be a 1 percent precision resistor. Its function is to control the current through the winding L1 by means of the voltage across the resistor, which determines the bias on the transistor Q1 when a fixed potential is applied to the base. As will appear, the current through the winding L1 during energization is very much greater than the small current components that flow through the resistor R4 and the diode D2, so that those components are negligible to the regulation achieved.

Typical component values employed in the circuit here shown, in accordance with a preferred embodiment of the invention, are as follows:

Resistors	Diodes	Transistors
R1 3.3K ohms	D1 1N283	Q1 2N3859A
R2 10K ohms	D2 1N283	Q2 2N2907
R3 150 ohms	D3 68 volts, 1 watt	Q3 2N5036
R4 470 ohms	1N4761	
R5 0.5 ohms		
B1=B2=+40 volts DC		
L1=5.5 ohms DC		

The operation of the apparatus of my invention will next be discussed, on the assumption that a line of characters to be printed has been entered in the line memory in the data processing unit 2. As each character pulse is produced, the results of the search of the memory for a corresponding character are strobed into the flip-flops F1 through F132. For each column in which the corresponding character is to be printed, the corresponding flip-flop is set, and for each column in which the character is not to be printed, the flip-flop is reset. The flip-flops F1 through F132 are thus loaded following the character pulse CP and before the production of the pulse FP.

Confining attention to the column 1 hammer firing circuit including the flip-flop F1, assume first that it is not set. The input terminal *a* of the gate G1 will accordingly remain at ground. When the pulse FP is produced, raising the potential at terminal *b* of the gate G1 the output terminal *c* of the gate C1 will remain at ground potential. Thus, the transistors Q1 will not be raised into conduction. Accordingly, the transistor Q2 will be cutoff by the positive potential applied through the resistor R2 to its base. With the transistor Q2 cut off, not current will flow through the resistor R4 and the transistor Q3 will remain unbiased and cut off.

Next, assume that the flip-flop F1 34 is set following a character pulse CP. When the pulse FP is produced, the potential of the output terminal *c* of the gate C G1 will go to 2.25 volts. That will bias the transistor C1 into conduction causing the current to flow from the positive terminal +B1 through the resistor R2, from the collector to the emitter of the transistor Q1, through the diode D2, and through the resistor R5. The reduced potential at the collector of the transistor Q1 will bias the transistor Q2 into conduction, allowing current to flow the supply terminal at +B1 through the resistor R3, from the emitter to the collector of the transistor Q2, and through the resistors R4 and R5 to ground. The voltage drop across the resistor R4 will now bias the transistor Q3 into conduction, allowing energizing current to flow from the source terminal +B2 through the solenoid winding L1 from the collector to the emitter of the transistor Q3 and through the resistor R5 to ground. All of these events will of course take place quite rapidly.

The current through the winding L1 will be held to 2.5 amperes by controlling weight impedance between the collector and emitter of the transistor Q3. The voltage across the resistor R5 will be established by the transistor Q1 at 1.25 volt. Should this voltage tend to rise, the base-emitter bias on the transistor Q1 will be reduced, raising the potential on the collector of

the transistor Q1 and thereby reducing the biasing voltage on the base-emitter junction of the transistor Q2. That will reduce the potential across the resistor R4, thereby increasing the impedance between the collector and the emitter of the transistor Q3.

Should the voltage across the resistor R5 tend to fail, forward bias on the transistor Q1 will be increased, reducing the potential of the collector of the transistor Q1 and increasing the bias of the transistor Q2. That will allow a larger current to flow through the resistor R4, and reduce the impedance presented by the collector-to-emitter path of the transistor Q3 thus supplying more current through the winding L1 and the resistor L5. Thus, precise current control action, determined by the level of the voltage established at the terminal *c* of the gate G1 is effective in the presence of minor variations of the power supply voltage +B2 which occur by reason of the different numbers of solenoids such as L1 which may be energized at any given time. Regulation of plus or minus 5 percent in the 40-volt supply is readily accommodated without noticeable variations in print quality.

At the end of the pulse, FP, the voltage at input terminal *a* of the switch S1 will fall, cutting off the transistor Q1. The voltage at the collector of the transistor Q1 will rise, cutting off the transistor Q2. That will tend to cut off the transistor Q3 interrupt the flow of current through the winding L1. The resultant inductive kick will cause the 68-volt zener diode D3 to break down, thereby protecting the transistor Q3 against excessive voltage. The transistor Q3 will then be cut off.

While I have described my invention with respect to the details of a preferred embodiment thereof, many changes and variations will occur to those skilled in the art upon reading my description, and such can obviously be made without departing from the scope of my invention.

Having thus described my invention, what I claim is:

1. In a high-speed printer, the combination of a group of registers settable to store signals indicating whether or not a character is to be printed in each of several columns, and AND gate for each register having two input terminals and an output terminal, a first of said input terminals being connected to said register, said gates each being responsive to a timing signal applied to the second input terminal and a signal stored by the corresponding register indicating that a character is to be printed to produce an output signal, each of said gates comprising a resistor having one terminal connected between said first input terminal and said output terminal and a diode connected between said second input terminal and said output terminal, pulse-generating means for simultaneously applying a timing signal to the second input terminals of said gates, and print control means connected to the output terminals of said gates and responsive to said output signals for printing characters in the columns directed by said output signals.

2. The apparatus of claim 1, in which said print control means comprises a source of electrical energy, a winding for each column, and an electronic switch for each winding connected in series with the winding and with said source and closed by said output signal.

3. The apparatus of claim 2, in which each electronic switch comprises means responsive to the level of said output signal to control the current flowing in said winding when said switch is closed to a value predetermined by the level of the output signal.

4. In a high-speed printer having a printing solenoid comprising a winding, a source of electrical energy, an electronic switch having load terminals connected in series with said winding and said source, said switch having a control terminal and being closed when a predetermined potential is applied to said control terminal with respect to one of said load terminals, storage means having a first output terminal settable to a first or a second potential, a resistor connected between said first output terminal and said control terminal, a pulse generator having a second output terminal and actuable to produce a pulse between said first and said second potential on said second output terminal, and a diode connected between said

second output terminal and said control terminal, said predetermined potential being between said first potential and said second potential.

5. The apparatus of claim 4, wherein which said switch comprises a variably impedance and a fixed impedance connected between said load terminals, and means responsive to the voltage across said fixed impedance when said switch is closed and to the potential on said control terminal for adjusting said variably impedance to fix the current between said load terminals.

6. In combination, a first terminal, pulse-generating means operable to apply a pulse of predetermined amplitude and duration to said first terminal, a set of gates each having first and second input terminals and an output terminal, said first terminal being connected to each of said first input terminals, each gate comprising a diode connected between said first input terminal and said output terminal and a resistor connected between said output terminal and said second input terminal, a set of registers, each connected to a different one of said second input terminals and each settable to apply a first or a second signal to the corresponding second input terminal, whereby each output terminal produces a first or a second output signal when said pulse is present according as the corresponding register applies said first or said second signal to the second input terminal of the corresponding gate, an electronic switch connected to the output terminal of each gate and closed when said first output signal is present, a source of electrical energy, and a different winding connected in series with each switch and with said source.

7. The apparatus of claim 6, further comprising an operational amplifier connected between said first terminal and said first input terminals.

8. The apparatus of claim 7, in which each switch comprises a variably impedance and a fixed impedance connected in series with said winding and said source, and means responsive to the voltage across said fixed impedance when said switch is closed and to said output signal for controlling the current through said fixed impedance to value determined by the amplitude of said output signal.

9. In a high-speed printer, a group of hammer-driving solenoids each having a winding, an electrical source, a group of electronic switches, one for each winding, each of said switches having load terminals connected in series with said source and with a different one of said windings, each of said switches having a control terminal, a group of control circuits, one for each switch, each control circuit comprising an output terminal connected to a different one of said control terminals and two input terminals, each of said control circuits comprising a resistor connected between a first of said input terminals and said output terminal, each of said control circuits comprising a diode connected between the second of said input terminals and said output terminal, a group of register means, one for each control circuit, for storing a signal indicating whether or not a winding is to be energized, each register means being operatively connected to a different one of said first input terminals to close the associated switch when and only when the stored signal indicates the associated winding is to be energized and a predetermined second signal is applied to the second input terminal of the control circuit, and pulse-generating means connected to all of said second input terminals and actuable to apply said second signal to said second input terminals for a predetermined time.

10. The apparatus of claim 9, in which said switches each comprise a variable impedance and a fixed impedance connected in series with said load terminals, and means responsive to said second signal and the voltage across said fixed impedance for controlling said variable impedance to maintain the current through said load terminals substantially constant when said switch is closed.

11. In a high-speed printer comprising a group of electromagnetic windings each energizable to effect printing in a different column, a control circuit comprising a source of electrical energy, current control means for each winding con-

nected in series with that winding and said source and responsive to the amplitude and duration of an applied signal for supplying current from said source to energize the winding in an amount determined by the amplitude of the applied signal for the duration of the applied signal storage means for each winding for storing a signal indicating whether or not the winding is to be energized, signal generating means operable to produce a signal having a predetermined amplitude and duration, and gate means controlled by said storage means and said pulse-generating means for supplying a signal resistor an amplitude and duration determined by the amplitude and duration of the signal produced by said signal generating means to each of said current control means for which the corresponding storage means is storing a signal indicating that the corresponding winding is to be energized, each of said gate means comprising a diode having a first terminal connected to said signal-generating means and a second terminal connected to the corresponding current control means, and a resistor connected between the second terminal of the diode and the corresponding storage means.

12. In combination, a set of storage means each having an output terminal and actuable to produce a first or a second voltage on said output terminal, a resistor for each storage means having a first terminal connected to said output terminal and a second terminal, a diode for each resistor having a first terminal connected to said second terminal of the resistor and a second terminal, and pulse-generating means connected to the second terminals of all the said diodes and actuable to apply a pulse of voltage between said first voltage and said second voltage to said second terminals.

13. The apparatus of claim 12, further comprising an electronic switch for each resistor, each switch being connected to the second terminal of the resistor and closed when and only when said pulse is applied to said second terminal of the corresponding diode and said second voltage is applied to the first terminal of the resistor, a source of electrical energy, and an electromagnetic winding for each switch connected in series with the switch and said source.

14. In combination, a plurality of register means for storing a corresponding plurality of signals each having a first value or a second value, a gate for each register means, each gate comprising a resistor having one terminal connected to the corresponding register means to receive said signal, a diode having two terminals for each resistor, each resistor having a second terminal connected to one terminal of the corresponding diode, pulse-generating means connected to the other terminal of said diodes and actuable to apply a pulse of predetermined amplitude and duration to said diodes and to bring the signals at the junctions of said diodes and said resistors to first or second values determined by the amplitude of said pulse and the presence of said first or said second signal applied to the corresponding resistor, a winding for each register means, a source of electrical energy, and switching means for each winding connected in series with the winding and with the source, each of said switching means being connected to a different one of the junctions of said resistors and diodes for closing or not closing a circuit path between said source and the corresponding winding according as the signal at the junction when said pulse is produced has said first or said second value, respectively.

15. A print control circuit for a high-speed printer in which there are a group of electromagnetic coils each energizable to effect printing in a different column, comprising a source of electrical energy, a different switching means connected in series with each of said coils and with said source and responsive to an applied signal to supply or not supply energy from said source to said coil according as said signal has a first or a second value, respectively, gate means for each switching means comprising a resistor and a diode each having a first terminal and a second terminal, said first terminals of each resistor and diode being connected together and to said switching means to apply a signal to the switching means determined by the potential at said first terminals, storage

means for each gate means for applying a first or a second potential to the second terminal of the resistor according as the corresponding coil is to be energized or not energized, respectively, and pulse-generating means connected to the second terminal of all of said diodes and actuable to apply a

pulse to said second terminals produce said first signal or said second signal at the said first terminals according as the corresponding storage means is applying said first or said second potential to the second terminal of the corresponding resistor.

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