ABSTRACT OF THE DISCLOSURE

Excessive voltage reduction at the output of the hammer driver power supply in a high speed line printer is prevented by temporarily inhibiting the generation of a "paper feed" command under certain conditions, thereby delaying the occurrence of the next print cycle and allowing the power supply to recharge to its normal output level. A first inhibiting condition is set up by completion of the print cycle at an unusually early time. In such an instance the feed command is delayed by an inhibit pulse of predetermined duration generated by a one-shot multivibrator triggered at the start of the print cycle. A second inhibiting condition is set up by decrease in the power supply output voltage to below a predetermined level. In this instance the feed command is delayed by an inhibit pulse of predetermined duration generated by a one-shot multivibrator triggered by a voltage level detection circuit connected to the power supply output line.

My invention relates to high speed printers, and particularly to a novel control means for regulating the printing rate and print quality of line printers.

High speed printers of the kind commonly used today are conventionally designed to a specified average printing rate; for example, 300, 600 or 1200 lines per minute. In order to attain these average rates, such printers are commonly provided with a type carrier such as a band, print roll or the like, constantly moving with respect to a bank of hammers or other printing elements. The operating cycle of such printers is divided into a period during which paper is moved to a new printing position, and a period in which the actual printing is accomplished. To avoid requiring the printer to operate synchronously with a data source, a buffer memory, such as a core plane memory matrix or the like, may be provided, into which a line of characters to be printed is loaded during the paper feed cycle. The paper feed portion of the cycle is normally a fixed time, such as 15 milliseconds for a 1200 line per minute printer, although a longer period may elapse at times when it is desired to feed the paper more than one line position at a time. In order to avoid lost time in printing after the paper feed operation is completed, it is common practice to arrange printers to begin printing as soon as a character to be printed is in printing position on the type carrier. If it should happen that most of the characters in a line to be printed come into position together, or at nearly the same time, it may happen that the actual printing portion of the cycle will be extremely short. A second similar line may follow, so that the time between lines will approach the paper feed time. At such times, the printer is actually printing at a rate very much higher than its designed average rate, although very little contribution is made to the average line rate because the occurrences of such short printing cycles are relatively rare. However, in order to provide uniform print quality, the printer must be designed to produce satisfactory print under any conditions of operation. The principal difficulty encountered in designing a printer to operate occasionally at very high printing rates is that the printing elements, such as the print hammers conventionally employed, require relatively large amounts of energy to operate. This energy is conventionally provided by a power supply charging a bank of capacitors, the capacitors being discharged in the printing cycle as the various hammers are fired. It will be apparent that to provide the power necessary to fire, for example, all of 160 hammers to print a line of A's, feed paper, and then print the next character appearing after the paper feed cycle on a next succeeding line, would demand a power supply of very large size compared to that required to supply hammer actuating current at the average line printing rate. A second difficulty encountered when high printing rates occur is that mechanical resonances in the print hammers may prevent proper operation when the hammers are repeatedly actuated at a high frequency. These difficulties may be avoided by clocking the start of a print cycle with an index pulse generated once each revolution of the type carrier, but with a great loss in average printing rate. It is the object of my invention to reduce the power supply requirements of high speed printers while retaining a high average printing rate.

The object of my invention may be attained with the addition of but little equipment to a conventional high speed printer. Briefly, the apparatus of my invention comprises a demand detector connected to the power supply for the printing elements of the printer, a time delay generator, and a logic circuit controlled by these circuits for initiating the feeding of paper at a time determined by the demands made by printing of the previous line on the power supply. As will appear, the arrangement is such that there is very little effect on the average line printing rate, but the demand on the power supply is never greatly in excess of the demand made with respect to an average printing cycle. The manner in which the apparatus of my invention may be constructed and installed in a high speed printer will be made clear by the following detailed description, together with the accompanying drawing, of a preferred embodiment thereof.

In the drawing, the sole figure is a schematic wiring diagram of a high speed printer incorporating the demand controlled rate equalizer of my invention.

Referring now to the drawing, I have shown schematically certain basic elements of a conventional high speed printer of the type well known in the art and shown and described in somewhat more detail in U.S. application for Letters Patent Ser. No. 393,678, filed on Sept. 1, 1964 by David F. Sweeney for Fully Checked Electronic Printing System and assigned to the assignee of my application. The basic structure of the printer may be of any suitable design, for example as shown in U.S. Patent No. 2,940,385, granted on June 14, 1960 to Frank R. House for High Speed Printer, and in U.S. Patent No. 3,006,520, granted on Oct. 31, 1961 to Frank R. House for Paper Feed for High Speed Printers. Briefly, the basic apparatus comprises a type carrier such as a print roll 1, mounted on a drive shaft 3 for rotation by conventional means such as a motor 5. The shaft 3 carries a shaft encoder 7 of conventional design, for providing character pulses over a line 9 and character code sequences over a set of lines 11 to identify the location and identity of characters such as 13 on the print roll 1 as they come into printing position with respect to a line of printing elements such as a bank of print hammers 15, a typical hammer being shown schematically at 17. A font of characters 13 is provided for each column to be printed, and a hammer such as 17 is conventionally provided for each column, although one hammer may serve more than one column if desired, as is well known in the art.

The hammers 15 are provided with print hammer drivers 19. For each hammer such as 17, an actuating
solenoid 21 is provided that is supplied with operating current over a bus 23 when it is desired to actuate the hammer. The supply of current to each of the coils such as 21 is controlled by a switch, such as the transistor 25, having a control circuit as indicated at 27 which may be appropriately energized to render the transistor 25 conducting when it is desired to energize the solenoid 21. The individual circuits such as 27 are selectively energized under the control of the distributor 29 during a print cycle. The distributor 29 may comprise a conventional array of gates controlled by printer logic circuits 31 and timing means 33. The timing means 33 may be of the type shown and described in more detail in the above-cited application of David F. Sweeney, and basically acts in response to character pulses received over the line 9 to produce appropriately timed address signals for controlling the scanning of a memory 35 and the supply of characters from the memory to the printer logic circuits 31, where they may be compared with character code sequences supplied by the shaft encoder 7 over the shaft 11 in a manner well known in the art, to produce agreement signals over the line 37 for distribution to the individual hammer actuating circuits such as 27 when a character in printing position agrees with a character stored in memory for that column. The detailed arrangement of these circuits is well known in the art, and is not considered necessary to an understanding of my invention. A suitable arrangement, however, is shown in detail in the above-cited application of David F. Sweeney.

Actuating current for the print hammer drivers 19 is supplied to the bus 23 from a bank of capacitors such as 39 charged by a conventional power supply 41. The voltage across the capacitors 39 will fluctuate from a maximum value provided by the power supply 41 to a minimum value when the current demand of the print hammer drivers is at its maximum value. One purpose of the apparatus of my invention is to prevent this maximum value from going below a point which would cause deterioration of the print quality.

During the record feed portion of the printing cycle, a record sheet, conventionally single or multiple sheet, fan-fold paper, is advanced to a new printing position with respect to the print hammers 15 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.

A suitable pulse serving to set the flip-flop 52 when it is desired to feed paper may be produced by a conventional pulse generator, here shown schematically as a resistor 57 connected in series 55 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.

A suitable pulse serving to set the flip-flop 52 when it is desired to feed paper may be produced by a conventional pulse generator, here shown schematically as a resistor 57 connected in series 55 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.

A suitable pulse serving to set the flip-flop 52 when it is desired to feed paper may be produced by a conventional pulse generator, here shown schematically as a resistor 57 connected in series 55 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.

A suitable pulse serving to set the flip-flop 52 when it is desired to feed paper may be produced by a conventional pulse generator, here shown schematically as a resistor 57 connected in series 55 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.

A suitable pulse serving to set the flip-flop 52 when it is desired to feed paper may be produced by a conventional pulse generator, here shown schematically as a resistor 57 connected in series 55 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.

A suitable pulse serving to set the flip-flop 52 when it is desired to feed paper may be produced by a conventional pulse generator, here shown schematically as a resistor 57 connected in series 55 by means of a pair of tractors, not shown, driven by a pair of sprockets 43 and 45 on a paper feed shaft 47. The shaft 47 is rotated at times by a motor 49, when an electromagnetic clutch 51 is energized and an electromagnetic brake 53 is released. Energizing current is supplied to the clutch 51 by an amplifier 48 energized with the control of a flip-flop 52. The amplifiers and flip-flop may be of conventional construction, interconnected such that when the flip-flop 52 is set by a "feed paper" signal applied to its input terminal a the amplifier 48 will supply current to the clutch and the amplifier 50 will cease supplying current to the brake, starting the shaft 47 to rotate and advance paper. A conventional form control 55 is arranged to be driven by the shaft 47. This control may, for example, comprise a punched tape driven by the shaft 47 with respect to a photocell to provide "stop" signals indicating the location of successive printing line positions to reset the flip-flop 52 when the next line position has been reached.
that no characters remain stored in the memory 35 in the manner described in the above-cited application of David F. Sweetney, a "print complete" signal is generated by conventional means, here shown as by the momentarily closure of a switch 85. When the "print complete" signal is received, the flip-flop 81 is reset and the NOR gate 79 is enabled to produce a positive-going signal if there are no positive levels at the input terminals a and c. The output terminal c of the NOR gate 79 is connected to the output terminal of a conventional one-shot multivibrator 87. This multivibrator may be of conventional construction, and arranged to produce a positive output signal of predetermined duration in response to a positive-going transition supplied to its input trigger terminal T. Such a transition will be supplied at the leading edge of each "start print" signal produced by closure of the switch 83. In a printer having an average printing rate of 1200 lines per minute, in which the minimum paper feed time is 15 milliseconds, the duration of the output pulse produced by the multivibrator 87 may conveniently be made 15 milliseconds in duration. This will ensure that the power supply 41 has at least 30 milliseconds in which to recharge the capacitor bank 39 regardless of the actual duration of the printing cycle.

The operation of the apparatus of my invention will be apparent to those skilled in the art from the above description. Briefly, however, assume that the printer is given its most demanding task by printing a full line of characters of the same kind and then printing a full line of the first characters coming into printing position after the paper feed cycle has been completed and the "start print" signal is generated. Assuming that the paper has been advanced by the paper feed shaft to the position for printing the first line, a "start print" signal is produced, as by momentarily closing the start print switch 83, the flip-flop 81 will be set and the NOR gate 79 will be disabled. As soon as the line of characters to be printed comes into printing position, the printer logic circuits 31 will produce agreement signals to cause all of the print hammer drivers 19 to be energized. Depending on the orientation of the print roll 1 when the printing cycle is initiated, this may occur during the 15 millisecond pulse produced by the one-shot multivibrator 87, or after it has occurred. In either event, the power demand made by firing all hammers simultaneously or nearly so will cause the Zener diode 61 to block, resulting in the differential amplifier D and triggering the multivibrator 77 to produce its output pulse. At about the same time, the "print complete" signal will be produced as by closure of the switch 85, since all characters in the line have been printed. The gate 79 will thus be blocked beyond the 15 millisecond period by a maximum amount of 10 to 15 milliseconds. After that time, the gate 79 will produce an output signal to set the flip-flop 52 and advance the paper to the next printing location. Since a minimum of 30 milliseconds will have elapsed, the power supply 41 will have time to fully recharge the capacitors 39. Thus, printing of the next line, even though it may consist of the same characters, may be begun at once. Without the apparatus of my invention, the printing in the worst case just described would cause the printer to operate at an instantaneous rate of 3600 lines per minute, even though the average printing rate was only 1200 lines per minute. With the apparatus of my invention, with a 15 millisecond minimum print cycle time, the instantaneous rate in the worst case would be only 1900 lines per minute without much change in the average: 1200 lines per minute. It will be apparent that the design requirements on the power supply 41 will be greatly reduced in this manner.

While I have described the apparatus of my invention with respect to the details of a particular embodiment thereof, many changes and variations will occur to those skilled in the art upon reading my description, and such may obviously be made without departing from the scope of my invention.
for advancing a record sheet to a new printing position in response to a feed signal applied after a line has been printed and while the capacitor is recharging, a print rate equalizer comprising:

means operatively connected to said capacitor for producing a first inhibiting signal of predetermined duration when the amount of energy supplied by said capacitor during the printing of a line exceeds a predetermined value, a bistable register set to a first state by the start print signal and to a second state by the print complete signal for producing a second inhibiting signal in its first state, timing means actuated by said start print signal for producing a third inhibiting signal of predetermined duration, and gate means controlled by said inhibiting signals for applying a feed signal to said form feeding means each time at least two of said inhibiting signals are produced, said feed signal being applied at termination of the inhibiting signal which is last to persist.

6. In combination with apparatus operating or repetitive cycles each comprising a demand period and a second period and having a variable impedance electrical load supplied with current during said demand period by a power supply comprising a capacitor charged by a power source at a rate less than the maximum rate of power demand during said demand period, said apparatus comprising means for producing a first signal marking the beginning of each demand period and for producing a second signal marking the end of each demand period, an operation rate equalizer comprising:

a bistable register connected to said signal producing means and set to a first state by said first signal and to a second state by said second signal, sensing means operatively connected to said power supply to produce a third signal of predetermined duration when the energy demand during a demand period reaches a predetermined value, and gate means controlled by said register, and said sensing means for producing a signal marking the beginning of a second period when said register is in its second state and said third signal is absent.

7. A control system comprising, in combination:

a variable electrical load;
a power supply whose output voltage is a function of a previous load and the time elapsed since the previous load;
means for applying the load to the power supply during delayable demand periods;
means responsive to the power supply output voltage for developing a signal under predetermined power supply operating conditions;
and means responsive to the signal to delay a subsequent demand period.

8. The apparatus set forth in claim 6, further comprising:

timing means connected to said signal producing means for producing a fourth signal of predetermined duration in response to said first signal, and means for applying said fourth signal to said gate means such that said gate means produces said signal marking the beginning of a second period when said register is in its second state and both said third and fourth signals are absent.

References Cited

UNITED STATES PATENTS

2,799,222 7/1957 Goldberg et al. ------ 101—93
2,915,966 12/1959 Jacoby -------------- 101—93
2,915,967 12/1959 Gehring et al. ------- 101—93
2,940,385 6/1960 House ---------------- 101—93
2,941,188 6/1960 Fletcher -------------- 340—172.5
3,064,561 11/1962 Maudit -------------- 101—93
3,142,247 7/1964 Sweeney -------------- 101—93
3,247,788 4/1966 Wilkins et al. ------- 101—93

WILLIAM B. PENN, Primary Examiner.