July 1, 1969 S. P. MABON 3,452,853

PAPER DRIVE SYSTEM

Filed Oct. 10, 1966

Sheet 1 of 2

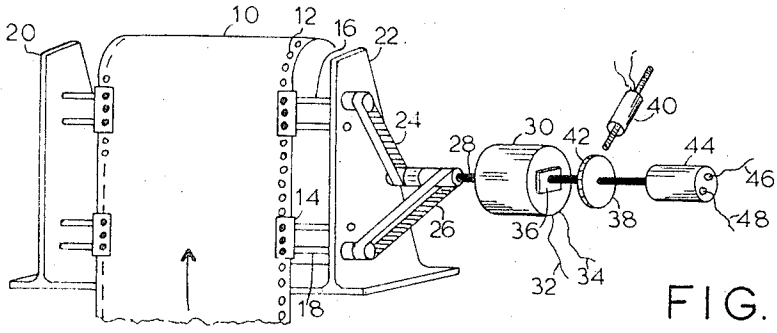


FIG. 1

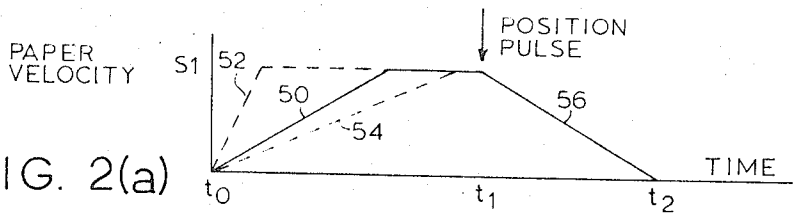


FIG. 2(a)

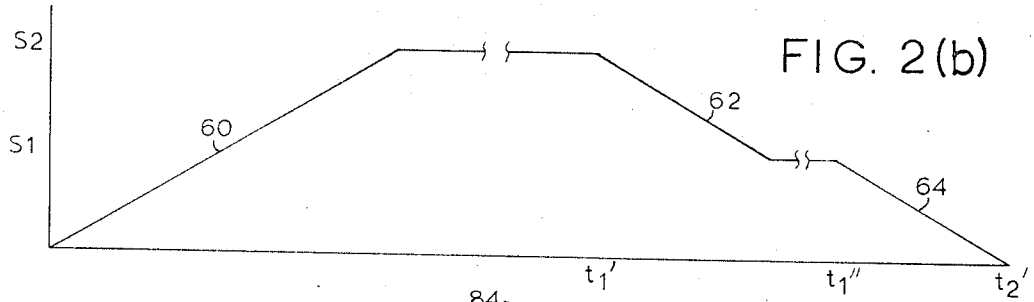


FIG. 2(b)

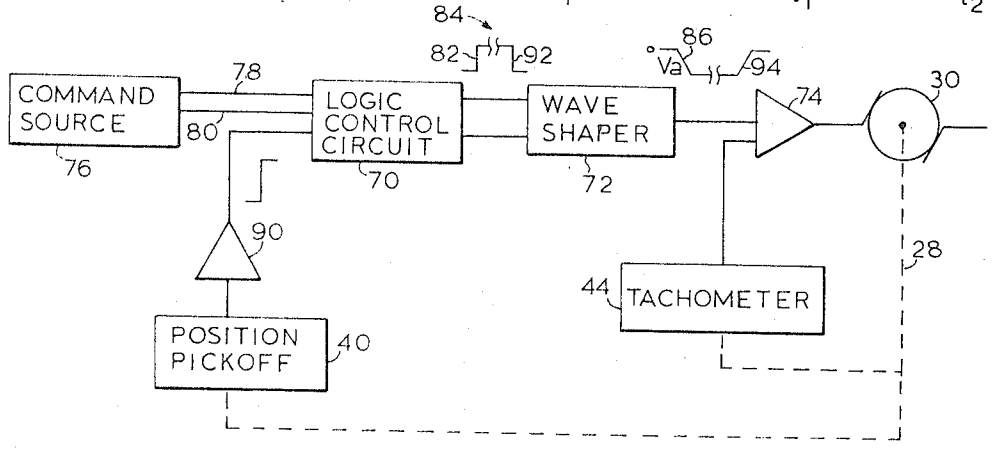


FIG. 3

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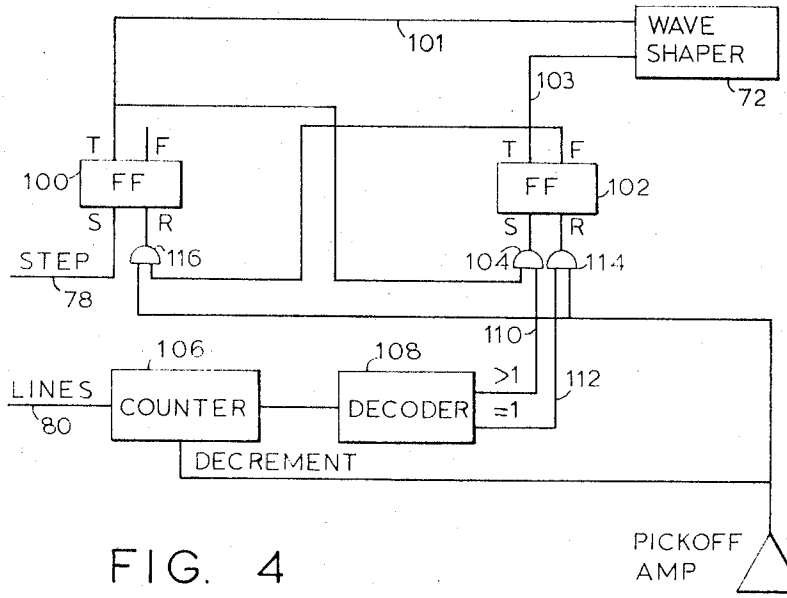


FIG. 4

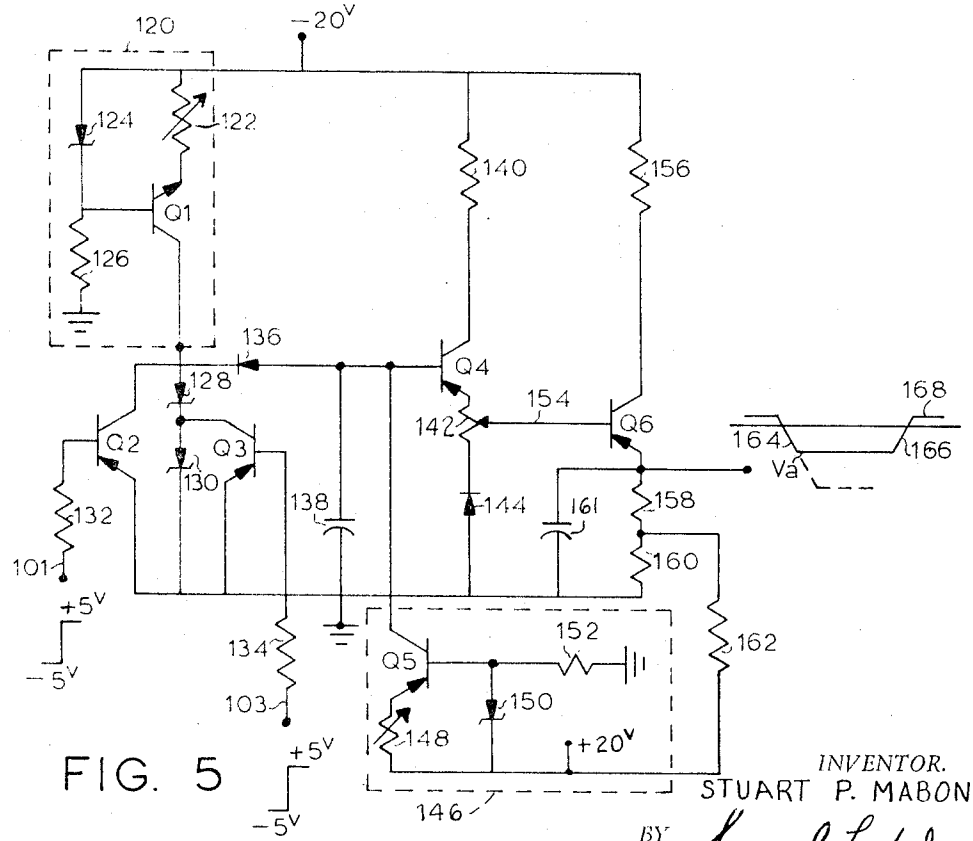


FIG. 5

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United States Patent Office 3,452,853
Patented July 1, 1969

3,452,853

PAPER DRIVE SYSTEM

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Filed Oct. 10, 1966, Ser. No. 585,666
Int. Cl. B41j 15/00; B65h 25/32, 25/02
U.S. Cl. 197—133 11 Claims

ABSTRACT OF THE DISCLOSURE

A system particularly useful for incrementally driving paper past a printing hammer bank. The system includes a motor mechanically coupled to the paper. A velocity servo loop is provided to establish and maintain a predetermined motor velocity. Position sensing means are provided to sense the position of the motor shaft and to initiate a controlled deceleration of the motor shaft from a known position and a known velocity.

This invention relates generally to means for driving paper and the like past a printing or other operational station and finds particular utility in line printers for incrementally driving paper past a printing hammer bank.

Line printers which are often used with digital data processing equipment as output devices, include a printing station usually consisting of a plurality of aligned hammers or electrodes. A paper strip is usually incrementally driven past the printing station so that a full line of printing is performed each time the strip comes to rest. Although present state of the art printers are capable of very fast operation, on the order of one thousand or more lines per minute, attempts to even further increase the speed are oftentimes restricted by the rate at which the paper can be driven. That is, it is necessary after each line of printing to move the paper and permit it to settle in its new position before a subsequent line can be printed if aligned symbols and generally neat printing are to be achieved.

In order to move paper very rapidly, it is common practice to very quickly introduce a great amount of energy into the paper drive system as by actuating an electromagnetic clutch to couple the paper tractor shafts to a reservoir of mechanical energy. Deceleration is accomplished by releasing the clutch and applying a brake. Control over the application of torque, which is extremely important in high speed operation, to eliminate a long settling time, is difficult to obtain since the time constants of the devices are normally too large to allow the rapid changes of torque that are necessary. In addition, the clutch-brake system suffers from the wear of mechanical parts resulting in changes in characteristics. To illustrate this point, a magnetic particle clutch with suitable torque capability and a rated life of five million operations, allows for two weeks' operation of a one thousand line per minute machine, running for forty hours per week. Hydraulic systems and stepping motor systems have also been employed, but these require additional mechanical or electronic components in order to satisfactorily stop paper after a rapid increment.

In view of the shortcomings of known prior art apparatus, it is an object of this invention to provide an improved system for rapidly moving paper and the like.

Briefly, paper is rapidly and precisely moved in accordance with the present invention by providing a servo loop to establish a predetermined velocity of the paper from which a controlled deceleration is initiated in response to a position indicating pulse.

In accordance with a preferred embodiment of the

invention, a direct current permanent magnet printed armature motor is employed. A velocity servo loop is utilized which includes a direct current tachometer as the velocity measuring element. The tachometer output is fed back to the input of an amplifier driving the motor. Position information is provided by a magnetic pickoff in conjunction with an aluminum disc, mounted on the motor shaft, in which are embedded small iron inserts at 15° intervals around the circumference thereof. (The motor shaft rotates 15° for each line increment.)

When the paper is required to step one line, the command voltage is applied to the servo input and the motor, tractors, and paper accelerate to a velocity proportional to the input voltage level. Soon after reaching this velocity, the position disc induces a voltage in the pickoff element which initiates deceleration.

Although the use of a velocity servo system in a paper movement apparatus has many advantages over prior art techniques, a pure velocity servo system of course has little resistance to drift when at zero velocity and accordingly hammer impact could move the paper in either a forward or reverse direction. Therefore, in accordance with a significant feature of the present invention, an overrunning clutch is utilized to prevent motor rotation drift in a reverse direction. In order to prevent drift in a forward direction, a small current is provided to the motor when in its rest condition which supplies a reverse torque causing the clutch to engage.

In accordance with a further feature of the present invention, in order to slew the paper, i.e., to move it several lines at a time, means are provided for rotating the motor at an increased velocity, e.g., double the normal velocity. In order to stop the motor, its velocity is reduced to normal when the penultimate line is reached and then reduced to zero when the ultimate line is positioned.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in connection with the accompanying drawing, in which:

FIGURE 1 is a schematic illustration generally showing the mechanical features of a system in accordance with the present invention;

FIGURES 2(*a*) and 2(*b*) illustrate a pair of waveforms generally representing the operation of a motor in accordance with the present invention;

FIGURE 3 is a block diagram illustrating the electrical configuration of a system in accordance with the present invention;

FIGURE 4 is a block diagram illustrating in greater detail the logic circuit of FIGURE 3; and

FIGURE 5 is a schematic diagram illustrating in greater detail the waveshaping circuit of FIGURE 3.

Attention is now called to FIGURE 1 of the drawing which illustrates the mechanical features of a paper drive system in accordance with the present invention. Such a system is employed in line printers for example for incrementally moving the paper past a printing station. Normally, the paper is moved one line at a time in a step mode. However, most line printers also are capable of operating in a slew mode in which the paper can be moved through several lines.

FIGURE 1 illustrates a typical strip of paper **10** adapted to be utilized in line printers. The paper **10** is moved past a printing station (not shown) which for example can be comprised of a bank of individually actuable impact hammers. Usually, the bank will include a number of hammers equal to the maximum number of characters to be printed in any one line. A printing ribbon will normally be disposed between the paper **10** and the hammer bank. A character drum normally rotates

adjacent the rear surface of the paper **10**. The character drum usually defines a plurality of tracks equal in number to the number of hammers in the bank. In order to print a particular character at a desired position in a line, the hammer associated with that position is propelled against the drum when the character to be printed is aligned with it. As a consequence, the printing ribbon and paper are moved against the drum, resulting in the character being printed on the front surface of the paper. After all of the characters in a line have been printed, the paper strip is stepped so that the next line can then be printed. In order to enable lines to be printed at a rate greater than one thousand per minute, it is of course necessary that the paper be stepped and stopped very rapidly. If printing is initiated before the paper settles, a very poor quality print will of course result. A system in accordance with the present invention is intended to very rapidly move and quickly and precisely stop the paper.

As is conventional practice, the paper **10** is provided with a series of holes **12** which run along both edges thereof. The paper **10** runs through guides **14** and is driven by tractor wheels (not shown) engaged with the holes **12**. The tractor wheels are carried by tractor shafts **16** and **18** which are mounted for rotation between brackets **20** and **22**. The tractor shafts **16** and **18** are respectively driven by webbed belts or the like **24** and **26**. The belts **24** and **26** are in turn driven by a shaft **28**.

The apparatus recited thus far is substantially conventional in nature. The present invention is primarily directed toward an improved system for controlling the rotation of the shaft **28** in order to rapidly and precisely drive the paper **10**. In accordance with the present invention, the shaft **28** constitutes the shaft of a motor **30**. Preferably, though not necessarily, the motor **30** comprises a direct current permanent magnet printed armature motor. A typical motor of this type is manufactured and sold by Photocircuits, Glen Cove, N.Y., under model No. U12C. Such motors can normally be driven in either a forward or reverse direction depending upon the polarity of the signal applied to the motor terminals **32** and **34**. In order to prevent backlash when the motor **30** is rapidly stopped, an overrunning clutch **36** is coupled to the motor shaft **28**. The overrunning clutch **36** functions to prevent motor rotation in one direction, i.e., a reverse direction, while freely permitting rotation in the forward direction. A suitable overrunning clutch is manufactured and sold by Miniclutch, Hamdon, Conn., under model No. HU7.

Also coupled to the shaft **28** is a disc **38** which enables the shaft's position to be determined by a position pickoff transducer **40**. Preferably, the disc **38** is formed of aluminum and has iron inserts **42** disposed therein around the periphery thereof at equal intervals. For example, if the spacing between lines to be printed on the paper **10** is equivalent to a 15° rotation of the shaft **28**, then the disc **38** will have iron inserts **42** disposed therein at 15° intervals. The position pickoff transducer **40** can comprise a conventional magnetic pickup which senses the proximity of the low reluctance magnetic inserts **42**. Also connected to the shaft **28** is a tachometer **44**. Preferably, the tachometer **44** provides a direct current output voltage on its terminals **46** and **48** which is linearly related to the shaft velocity **28**.

Attention is now called to FIGURES 2(*a*) and 2(*b*) which are comprised of waveforms generally illustrating the concept of the operation of a system in accordance with the present invention. More particularly, FIGURE 2(*a*) comprises a plot of shaft or paper velocity versus time. Let it be assumed at time t_0 a command signal is generated which is intended to move the paper **10** through one line. In accordance with the present invention, the shaft **28** is accelerated to increase its velocity or rotational speed from zero to a first predetermined level **S1**. This acceleration is represented by the ramp portion **50** of the curve of FIGURE 2(*a*). It is to be understood however that the shaft **28** need not be accelerated along the line **50** but indeed the acceleration could be at other rates as for example represented by dotted line ramps **52** and **54**. The advantage of following dotted line ramp **52** for example (as opposed to ramps **50** and **54**) is that the shaft **28** can be moved to its next position more rapidly inasmuch as will be seen a greater porition of its cycle time is spent at a higher velocity. The disadvantage of traversing a sharp ramp **52** is that longer life can be assured in any mechanical system by minimizing the magnitude of acceleration. Contrariwise, the disadvantage of following a ramp such as is represented by line **54** is that the paper **10** cannot be stepped as rapidly but longer maintenance-free life is probably assured. Ramp **50** represents somewhat of a compromise between ramps **52** and **54**. In addition, the slope of ramp **50** is illustrated as being identical with the slope of a negative acceleration or decelerating ramp **56** which can enable certain circuit economies to be taken advantage of.

Regardless of which particular acceleration path (**50**, **52**, or **54**) is followed, the shaft **28** is positively accelerated from time t_0 from a velocity of zero to the predetermined velocity **S1**. As previously noted, the velocity **S1** is maintained by a velocity servo system to be discussed in greater detail hereinafter. At some subsequent time, e.g., t_1, the position pickoff transducer **40** will provide a pulse in response to the next iron insert **42** moving into proximity therewith, indicating that the shaft **28** is almost properly positioned. In response to the pulse, the shaft **28** is thereafter negatively accelerated along ramp **56**. Since the position and velocity of the shaft **28** is known at the time the position pulse is generated by the transducer **40**, and since the slope of deceleration as represented by the ramp **56** is known, the velocity of the shaft **28** should reach zero (as at time t_2) when the shaft **28** is in proper position, i.e., the paper **10** is properly oriented with respect to the printing station for the next line to be printed.

It is to be noted that the area under the curve of FIGURE 2(*a*) between times t_1 and t_2 represents the integral of velocity with respect to time or in other words the distance that the paper **10** travels subsequent to the time the position pulse is generated. Since the generation of the position pulse is a reference, the only error that can be introduced in the ultimate position at which the paper **10** stops is introduced between times t_1 and t_2. Inasmuch as the distance traveled between times t_1 and t_2 normally represents only a small fraction, e.g., one-third, of the total distance traveled in a single step, i.e., between times t_0 and t_2, then the effect of any percentage error introduced during stopping between times t_1 and t_2 has a lesser effect on the total stepping distance. In other words, if a ten percent error in the stopping distance is introduced between the time the position pulse is generated and zero velocity is achieved, this error will result in only a three percent (10%/3) error in the total paper step.

Whereas FIGURE 2(*a*) generally illustrates the operation of a system in accordance with the present invention in order to move the paper **10** through a single step, the curve of FIGURE 2(*b*) illustrates the operation when the paper **10** is moved in a slew mode, i.e., moved through two or more steps. In this situation, the shaft **28** is accelerated, as along ramp **60**, until it reaches a second predetermined velocity **S2**. The velocity servo system then maintains the velocity **S2** while the number of lines to be skipped is decremented each time a pulse is provided by the transducer **40**. When the penultimate line is reached, the position pulse generated by the transducer **40** as at time t_1' will decelerate the motor **30** along ramp **62** to velocity **S1**. When the next position pulse is recognized as at time t_1'', the shaft **28** will be decelerated along ramp **64** down to a zero velocity at time t_2'.

From the foregoing, it should be appreciated that in accordance with the present invention, a drive member,

such as shaft **28**, driving a load, such as paper **10**, is positively accelerated up to a predetermined velocity at which it is maintained by a velocity servo means. After a pulse is generated in response to the drive member **28** reaching a reference position, the drive member **28** is negatively accelerated or decelerated in order to reduce its velocity from the predetermined level to zero. An electrical configuration for controlling the shaft **28** in accordance with the curves of FIGURES 2(*a*) and 2(*b*) is illustrated in FIGURE 3.

A logic control circuit **70** is shown in FIGURE 3 which controls, through a waveshaping circuit **72**, an amplifier **74** driving motor **30**. The logic control circuit **70** is responsive to signal information provided by a command source **76**. Thus, the command source **76** can command a single step movement of the paper **10** as for example providing a true logical level on line **78**. In order to command a multistep paper movement, a true logical level is provided on line **78** and the number of lines to be stepped is represented by information provided on line **80**.

Assume for example that the paper **10** is to be moved through a single step. As a consequence, the command source **76** will provide a pulse on line **78** to the logic control circuit **70** to switch it to a true state as represented by the step **82** in signal **84** illustrated at the output of the logic control circuit **70**. In response to this step **82**, the wave-shaping circuit **72** will provide a ramp signal **86** to the amplifier **74** to thus accelerate the motor **30** from a zero velocity toward the velocity **S1**. The motor shaft **28**, as previously noted, is coupled to the tachometer **44** and the position pickoff transducer **40**. The output of the tachometer **44** is coupled back to the input of amplifier **74**. Accordingly, in response to the ramp signal **86**, the motor shaft **28** will be driven to the predetermined velocity **S1** and will be maintained there as a consequence of the feedback through the shaft **28** to the tachometer **44** to the amplifier **74**. It will be appreciated that this configuration comprises a conventional feedback servo loop. As is well known to those skilled in the art, by properly choosing the characteristics of the feedback loop, the velocity of the shaft **28** can be maintained at the desired level inasmuch as if it increases above a value set by the input signal, then an error signal will be provided to the amplifier to change the shaft velocity to correspond to that dictated by the input signal.

The output of the position pickoff transducer **40** is coupled through an amplifier **90** to the input of the logic control circuit **70** to switch the circuit **70** back along step **92** when the reference position of the shaft **28** is recognized during the last step of the paper movement. The step **92** causes the wave-shaping circuit **72** to provide a ramp output signal **94** to decelerate the motor **30** in the manner previously disclosed; i.e., along the ramp **56** as shown in FIGURE 2(*a*).

Attention is now called to FIGURE 4 which comprises a block diagram illustrating a typical configuration for the logic control circuit **70** of FIGURE 3. The logic control circuit **70** includes first and second flip-flops **100** and **102** which can be considered to be of the conventional set/reset type. The step input line **78** from the command source **76** is connected to the set input terminal of flip-flop **100**. The true output terminals of the flip-flops **100** and **102** are respectively connected through lines **101** and **103** to input terminals of the wave-shaping circuit **72**. In addition, the true output terminal of flip-flop **100** is connected to the input of an AND gate **104** whose output is connected to the set input terminal of the flip-flop **102**. The line count input line **80** from the command source **76** is connected to the input of a counter **106** whose output is connected to the input of a decoder **108**. In the event the counter **106** stores a count greater than one, a true output signal is provided on decoder output line **110** connected to the input of AND gate **104**. Thus, if the flip-flop **100** is set and the counter **106** stores a count greater than one, indicating that the paper **10** has to be stepped through more than one line, the flip-flop **102** is set through AND gate **104**. If the counter **106** defines a count of one, then the decoder **108** will provide a true output signal on its output line **112**. The output line **112** is connected to the input of AND gate **114** whose output is connected to the reset input terminal of flip-flop **102**. The false output terminal of flip-flop **102** is connected to the input of AND gate **116** connected to the reset input terminal of flip-flop **100**. The output of the pickoff amplifier **90** (previously shown in FIGURE 3) is connected to the input of AND gates **114** and **116** and in addition is connected to a decrement input terminal of the counter **106**.

In the operation of the logic control circuit **70** of FIGURE 4, consider initially that a single step command is provided by the command source **76**. In this event, only the flip-flop **100** will be set. As will be described in greater detail hereinafter, the waveshaper **72** will provide a ramp output signal to a voltage level Va_1 which accelerates the shaft to the velocity Sl_1 in response to the flip-flop **100** switching true. When the shaft **28** moves sufficiently to induce a pulse in the magnetic pickup **40**, the pulse will be transferred by the pickoff amplifier **90** to the AND gate **116**. Assuming that the flip-flop **102** had not been set, it will still define a false state and as a consequence, the flip-flop **100** will be reset to thereby initiate the voltage ramp **94** shown in FIGURE 3 to in turn decelerate the motor **30** along the ramp **56** shown in FIGURE 2(*a*). Assume now that a multistep command is provided by command source **76**. In this case, the number of lines to be stepped is loaded into the counter **106** through line **80**. Thus, when the flip-flop **100** switches true, it will enable gate **104** such that flip-flop **102** will be set as a consequence of the counter **106** providing a count greater than one. As will be seen hereinafter, in response to both input terminals of the wave-shaper **72** being true, it will provide an output voltage ramp which increases to a greater voltage Vb (e.g., $Vb=2Va$) than is employed for the single step command. Thereafter, the velocity servo loop will maintain the shaft velocity at the second predetermined velocity S_2.

As the shaft **28** rotates, for each line, the pickoff amplifier **90** will provide a decrementing pulse to the counter **106**. When the counter **106** is stepped down to a count of one, the decoder output line **112** will go true so as to reset the flip-flop **102** when the next pulse is provided by the pickoff amplifier **90**. As a consequence, flip-flop **102** is reset and as will be seen hereinafter, the output of the wave-shaping circuit **72** will reduce to the first voltage level Va corresponding to the first predetermined velocity **S1**. In response to the next line position of the shaft **28**, the pickoff amplifier **90** will provide a pulse through gate **116** to reset the flip-flop **100** to thereby reduce the voltage output of the wave-shaper **72** along a ramp to a zero value to therefore negatively accelerate the shaft **28** as along a ramp **64** in FIGURE 2(*b*).

Attention is now called to FIGURE 5 which illustrates a circuit diagram of a typical wave-shaping circuit **72** which possesses the previously described operational characteristics. Thus, the wave-shaping circuit **72** of FIGURE 5 is comprised of a first constant current source **120** consisting of a variable resistor **122** connected between the emitter of an NPN transistor Q1 and a source of negative potential, nominally −20 volts. A zener diode **124** is connected between the source of negative potential and the base of transistor Q1. The base of transistor Q1 is connected through a resistor **126** to ground. The collector of transistor Q1 constitutes the output terminal of the constant current source and it is connected through a pair of serially connected Zener diodes **128** and **130**. The collector emitter path of a PNP transistor Q2 is connected across the Zener diodes **128** and **130**. The base of transistor Q2 is connected through a resistor **132** to the previously mentioned true output terminal **101** of flip-flop **100**. The collector emitter path of PNP transistor Q3 is connected across the Zener diode **130**. The base of transistor Q3 is

connected through a resistor **134** to the true output terminal **103** of flip-flop **102**.

The collector of transistor Q1 is connected through a diode **136** to a capacitor **138** and to the base of a PNP transistor Q4 connected in an emitter follower configuration. That is, the collector of transistor Q4 is connected through a resistor **140** to the source of negative potential previously mentioned. The emitter of transistor Q4 is connected through a resistor **142** and a diode **144** to the source of ground potential previously mentioned.

Also connected to the upper terminal of capacitor **138** is a second constant current source **146** substantially identical to the constant current source **120**. More particularly, constant current source **146** includes a PNP transistor Q5 whose collector is connected to the upper terminal of capacitor **138**. The emitter of transistor Q5 is connected through a variable resistor **148** to a source of positive potential, nominally shown as +20 volts. A Zener diode **150** is connected between the base of transistor Q5 and the source of positive potential. A resistor **152** is connected between the base of transistor Q5 and the previously mentioned source of ground potential.

A movable tap **154** associated with the resistor **142** connected to the emitter of transistor Q4 is connected to the base of a PNP transistor Q6 whose collector is connected through a resistor **156** to the previously mentioned source of negative potential. The emitter of transistor Q6 is connected through series resistors **158** and **160** to the source of ground potential. A capacitor **161** is connected in parallel with the resistors **158** and **160**. The junction between the resistors **158** and **160** is connected through a resistor **162** to the source of positive potential.

In the operation of the circuit of FIGURE 5, initially assume that when the flip-flops **100** and **102** define false states, they provide negative voltages, e.g., −5 volts on their true output terminals **101** and **103**. On the other hand, assume that when the flip-flops **100** and **102** switch true, they provide positive output voltages on the terminals **101** and **103**. Accordingly, when the flip-flops **100** and **102** are in their false state, transistors Q2 and Q3 are both conducting. Accordingly, a substantially ground potential will be established at the collector of transistor Q1. As a consequence, transistors Q4 and Q6 will be held off such that the output terminal, i.e., the emitter of transistor Q6 will also be at substantially ground potential. Now assume that a single step command is provided meaning the flip-flop **100** switches true thereby providing a positive potential on line **101** to cut transistor Q2 off. Transistor Q3 remains on. Thus the potential established at the collector of transistor Q1 will be equal to the reverse voltage drop across the Zener diode **128**. As a consequence, the capacitor **138** will charge to the level established by the Zener diode **128** at the collector of transistor Q1. The transistor Q4 will therefore conduct driving the potential on its emitter and the tap **154** negative. Consequently, the output appearing on the emitter of transistor Q6 will also be driven negative to define the ramp **164** whose slope will be determined by the charging time constant of the circuit including capacitor **138**. The setting of the variable resistor **122** will determine the rate of charge or the slope of the ramp **164**. The setting of tap **154** on resistor **142** will determine the magnitude of output voltage to be established on the emitter of transistor Q6. When the pickoff amplifier **90** provides a pulse to reset the flip-flop **100**, the transistor Q2 will start conducting again and the capacitor **138** will recharge from the constant current source **146** to thereby establish the output ramp **166** whose slope is determined by the setting of variable resistor **148**.

In the case of a multistep command, both transistors Q2 and Q3 will be cut off, thereby establishing a voltage at the collector of transistor Q1 determined by the serial drop across Zener diodes **128** and **130**. Accordingly, the capacitor **138** will charge to twice the voltage to which it was charged in the case of a single step command. Its rate of charge or time constant will however be the same assuming the value of resistor **122** has not been adjusted. As previously described in conjunction with FIGURE 4, the velocity of the shaft **28** is reduced in increments as shown in FIGURE 2(*b*) as by initially resetting the flip-flop **102** (to thus initially permit transistor Q3 of FIGURE 5 to start conducting) and to thereafter reset flip-flop **100** to subsequently permit transistor Q2 to start conducting.

As will be apparent to those skilled in the art, utilization of a velocity servo system as disclosed herein provides very little resistance to drift when the paper **10** is at rest. As a consequence, the impact of the hammers against the paper **10** during printing can move the paper **10** in a forward direction. The hammers will not of course move the paper **10** in a reverse direction inasmuch as the overrunning clutch **36** previously mentioned restricts the rotational direction of the shaft **28**. In order to prevent the paper **10** from moving in a forward direction, a small bleed current is provided to the motor **30** when in its rest state to provide a reverse torque which engages the overrunning clutch **36** and locks the motor **30**. This bleed current is provided to the output terminal connected to the emitter of transistor Q6 through resistor **162**. Thus as can be seen in the waveform illustrated at the output terminal of the circuit of FIGURE 5, when a voltage for driving the motor **30** is not being provided, a small bleed current as shown at **168** is being provided to introduce the reverse torque for locking the motor **30**.

From the foregoing, it should be appreciated that a drive system has been disclosed herein suitable for driving paper **10** in a line printer apparatus. To summarize briefly, a system in accordance with the invention employs a velocity servo system together with a position pickoff means in order to smoothly and rapidly decelerate a drive member **28** at a prescribed rate from a known position and velocity to bring the drive member **28** to rest precisely and rapidly. Moreover, in accordance with the invention, an overrunning clutch **36** is provided to prevent any backlash of the drive member **28** when it is being stopped. In addition, the overrunning clutch **36** is utilized to positively lock the drive member **28** when in its rest position. In addition, it should be appreciated that the system disclosed herein is applicable for moving the paper **10** in both single and multiple steps.

What is claimed is:

1. A drive system for precisely physically moving a load through one or more increments, each increment comprising a known distance, said system comprising:

a drive member coupled to said load;

drive means including motor means fixedly coupled to said drive member;

circuit means for applying signal energy to said motor means for accelerating said drive member from a zero velocity and servo loop means for establishing and maintaining said drive member at a preselected velocity;

position sensing means for providing a pulse in response to said drive member reaching a predetermined position; and

means responsive to said pulse for causing said circuit means to apply signal energy to said motor means to decelerate said drive member from said preselected velocity at a controlled rate.

2. The system of claim **1** wherein said drive member comprises a rotatable shaft of said motor means; and wherein

said circuit means further includes means for applying ramp signals to said motor means to respectively accelerate and decelerate said drive member.

3. In a high speed printing apparatus, a system for rapidly and precisely moving paper, said system comprising:

a drive motor including a rotatable shaft;

means directly coupling said shaft to said paper;

circuit means for applying signal energy to said motor to selectively either positively or negatively accelerate said shaft at a controlled rate;

means capable of defining a single step paper movement command;

control means responsive to the definition of said single step command for causing said circuit means to positively accelerate said shaft from a zero to a first preselected velocity;

sensing means for sensing the position of said shaft;

said control means further including means coupled to said sensing means and responsive to said shaft reaching a predetermined position for causing said circuit means to apply signal energy to said motor to negatively accelerate said shaft at a controlled rate from said first preselected velocity to said zero velocity.

4. The apparatus of claim **3** including servo means for regulating the velocity of said rotatable shaft.

5. The apparatus of claim **4** wherein said servo means includes a tachometer coupled to said shaft.

6. The apparatus of claim **3** wherein said sensing means includes elements carried by said shaft spaced around the periphery thereof; and

means for recognizing said element.

7. The apparatus of claim **3** wherein said drive motor comprises a reversible motor; and

clutch means for preventing rotation of said shaft in a first direction.

8. The apparatus of claim **7** wherein said circuit means includes means applying signal energy to said motor tending to drive it in said first direction when said shaft velocity is zero.

9. The apparatus of claim **3** wherein said circuit means includes means for generating a ramp signal having a predetermined slope for negatively accelerating said shaft.

10. The apparatus of claim **3** including means capable of defining a multistep paper movement command;

said control means being responsive to the definition of said multistep command for causing said circuit means to positively accelerate said shaft from a zero to a second preselected velocity.

11. The apparatus of claim **10** wherein said control means further includes means coupled to said sensing means for causing said circuit means to negatively accelerate said shaft from said second preselected velocity to said first preselected velocity.

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U.S. Cl. X.R.

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