

ABSTRACT: The impact time of an electrically driven-type element is directly sensed and employed to control a direct printer function, such as the impact drive itself or an ancillary printer function such as letter feed or data input control. Actual sensing of the impact point is preferably accomplished by observing the impact-force-induced polarity change of back EMF of a DC motor employed to drive the type element. Back EMF is also employed to control impact drive velocity.

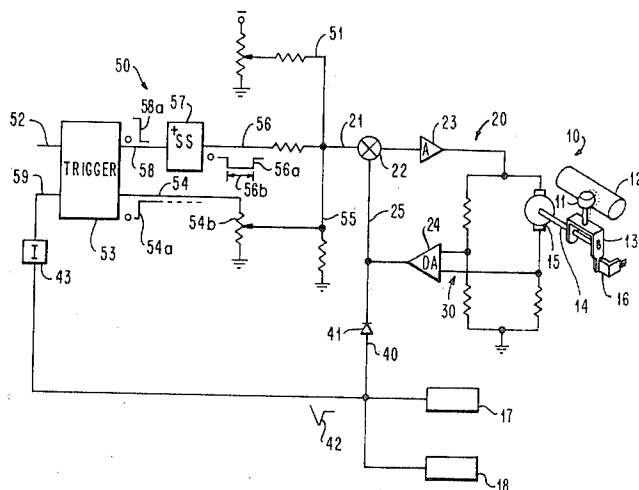


FIG. 1

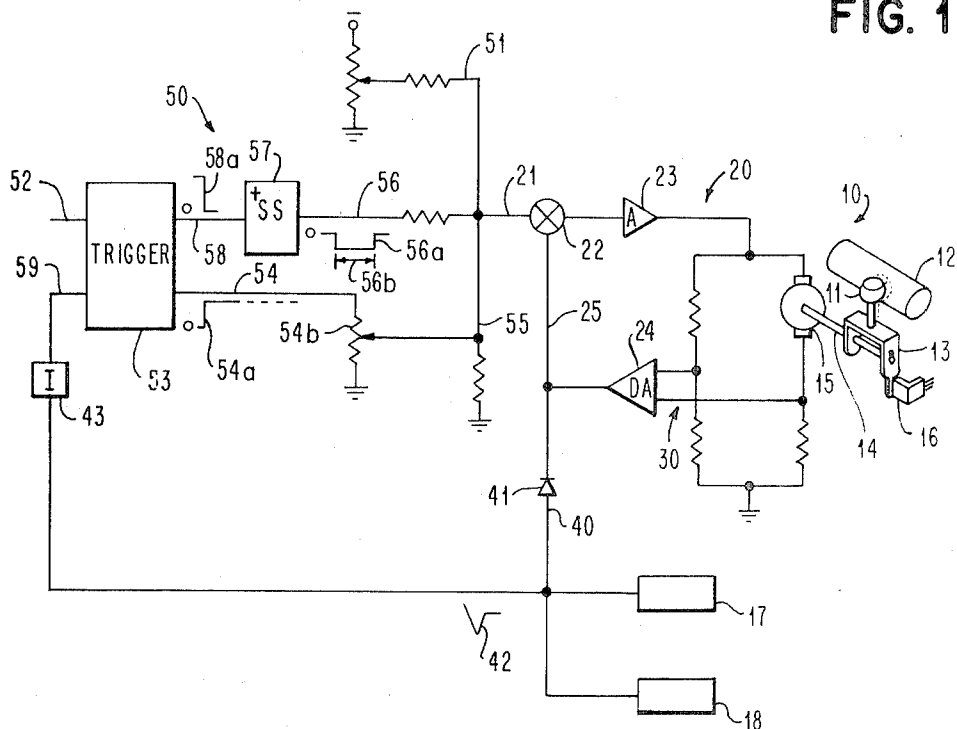
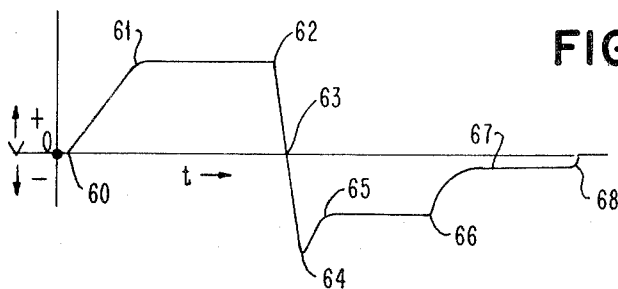


FIG. 2



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ELECTRICALLY DRIVEN-TYPE ELEMENT

BACKGROUND OF THE INVENTION

Impact printing has in the past been accomplished by direct mechanical drive of a type element and usually allows inertial free flight of the type element at the impact point. Also, impact printers have employed spring drives as well as electrical drives. Electrical drives have often used a simple solenoid, but occasionally a true motor has been proposed for this purpose. An electrical drive system offers a greater possibility for controlling print factors such as time and velocity and is especially convenient when employed in a system providing electronic control of other functions. Print speed and quality are each limited by the ability of the mechanism to be precisely and reliably controlled.

It has thus been an object of our invention to take advantage of the controllability of an electrical impact drive by providing a timing and velocity control therefor. A further object of our invention has been to provide accurate means for directly sensing the occurrence of print impact.

SUMMARY OF THE INVENTION

Our invention provides a direct-current, permanent magnet electric torque motor for driving a type element through an impact stroke. A bridge circuit for monitoring the back EMF produced by the motor is employed to detect the physical impact between the type element and platen. Any of several substantial changes in the characteristics of the back EMF can be observed to provide this detection. For example, the occurrence of zero back EMF indicates the total arrest of the type element. An abrupt decrease in the back EMF indicates deceleration of the type element due to impact. We prefer to observe the reversal of back EMF polarity that occurs upon the initiation of type element rebound. Each of these substantial changes in the characteristics in the back EMF is a direct result of the development of motion resisting impact force and this provides a more precise and reliable indication of the occurrence of impact than is available from indirect sensing, as for example, a switch placed in the path of a type element drive member.

We employ the impact-indicating signal thus developed to terminate or reverse the input drive to the type element to thus precisely terminate the print operation in a controlled and predictable manner. It is also possible to employ this same signal to initiate operation of a subsequent ancillary printer function such as letter feed or new data input.

A closed loop control of a selected impact velocity utilizing the back EMF produced by the motor is also provided to insure uniform image density under varying conditions of temperature, wear and lubrication of the parts. The nominal velocity that the type element is driven can be externally controlled to accommodate the needs of varied character size, imaging materials, and the number of copies being printed.

The variable velocity control necessarily causes variation in the time of print impact relative to the print cycle, however our direct impact sensing system described above automatically compensates for this variation without comprising print quality or speed. Thus impact drive is terminated and ancillary functions are initiated at the precise time desired as indicated by the precisely sensed point of impact.

These and other objects, features, and advantages of our invention will be apparent to those skilled in the art from the following detailed description of an illustrative preferred embodiment of our invention wherein reference is made to the accompanying drawing of which:

FIG. 1 is a simplified circuit diagram and abstract pictorial view of a typewriter having an electric impact drive and control therefor constructed in accordance with our invention, and

FIG. 2 is a velocity-time trace illustrating a typical motion of the impact drive system shown in FIG. 1.

Referring now more specifically to the drawing, in FIG. 1 there is shown a typewriter or printer 10 which in external

configuration can be similar to that disclosed in U.S. Pat. No. 2,919,002 and preferably could be employed in an electrically controlled typewriter system such as those disclosed in U.S. Pat. No. 3,297,124 and 3,417,202. Such typewriters employ a data input that identifies characters to be printed or functions to be performed and requires that at a given point in a processing cycle, a type-bearing member such as spherical type element 11 be driven through a printing stroke into impact cooperation with a paper-holding platen member 12. While either the type element 11 or the platen 12 could be movably mounted for the purpose of enabling impact, we prefer to mount the type element 11 on a rocker 13 for this purpose. Rocker 13 is connected by a shaft 14 to an electromechanical impact drive device such as a direct-current torque motor 15 preferably capable of operating continuously in a stalled condition.

The motor 15 is controlled by appropriate circuitry shown including as primary components, drive energy supply circuitry 20, a back EMF responsive bridge control circuitry 30, impact force detecting circuitry 40, and direction and velocity selection circuitry 50. These components of the overall circuitry control the motor 15 so as to produce a characteristic velocity trace similar to that shown in FIG. 2 where the plus and minus on the vertical axis represent forward (clockwise) and reverse velocity of the type element rocker 13 and the horizontal axis represents elapsed time beginning with zero at the time a print operation is initially selected.

A typical operation of type element 11 upon selection of a print operation begins at point 60 in FIG. 2 with constant acceleration of type element 11 to point 61 where its velocity is maintained at a substantially constant level right up to the point 62 where the type element 11 actually impacts the platen 12. The reaction force of impact begins to rapidly decelerate the type element 11 to zero velocity at point 63 and rebound begins with the type element 11 actually moving in the reverse direction away from the platen 12 to a maximum rebound velocity at point 64. During impact and particularly between points 63 and 64, the forward drive energization of the motor 15 is terminated and a reverse drive control is initiated that becomes fully effective at point 65 to maintain a constant reverse drive velocity of the type element 11 through point 66. This constant reverse velocity is somewhat less than the impact velocity between the points 61 and 62. At point 66 the reverse drive is terminated and a low-level bias drive applied which becomes fully effective at point 67 to provide a terminal restoration velocity control for the type element 11 up to point 68 where rocker 13 has returned counterclockwise to a point where it actually abuts a frame-mounted stop 16 and is thus arrested at this fixed position. The low-level bias drive is maintained to retain the rocker 13 in its rest position against stop 16 until a subsequent print operation is selected.

The normal or quiescent state of the typewriter 10 shown is produced by bias or holding circuitry 51 which applies a low-level reverse drive or negative signal to the input or velocity set point line 21 of an error-balancing feedback device such as a differential amplifier 22 to thus apply through power amplifier 23, low-level reverse drive energy to the motor 15 to retain the rocker 13 against the stop 16.

Selection of a print stroke is accomplished by application of a positive signal to the setline 52 of a bistable device such as a set-reset trigger 53 in the velocity and direction selection circuitry 50. Trigger 53 responds to the positive input on setline 52 by producing on its output line 54 a positive or forward drive control signal 54a. This signal 54a is modified by a velocity selection potentiometer 54b which can be varied to select different print velocities to accommodate variations in character size, imaging materials, and the number of copies being printed. The modified velocity drive signal is then applied to an analog adding device or circuitry 55 where it is algebraically added to the low-level negative signal from bias circuitry 51 to apply a resultant positive or forward driving signal to the input line 21 of feedback device 22. This signal will be amplified by power amplifier 23 to commence rotation of the motor 15 in the forward or impact driving direction.

Since initially the full velocity selection signal will be applied to the amplifier 23 due to the low back EMF sensed by the bridge circuitry 30 and applied by differential amplifier 24 to the feedback line 25 of the feedback device 22, a large saturating or self-limiting current will be applied to the motor 15 to produce the constant acceleration shown between points 60 and 61 on FIG. 2. At point 61 the velocity of motor 15 has become sufficient to produce a back EMF which when amplified is effective to be subtractive of the signal applied from the analog adding circuitry 55 to the feedback input line 21 thus reducing the set point signal as required to maintain the constant velocity between points 61 and 62. During this forward drive stroke, a reverse drive circuit portion 56 of the circuitry 50 has remained inactive as has the impact-indicating circuitry 40. A positive control, negative output single-shot device 57 in the reverse drive circuit portion 56 does not respond to the change of state of trigger 53 upon application of a signal at 52 since such signal will apply on output line 58 a down-going or negative signal 58a.

As type element 11 encounters platen 12 a reaction force is generated causing rapid deceleration of the element 11 and the motor 15 from point 62 through a zero velocity point 63 and into a rebound or reverse motion. When the motor 15 is driven by the rebound of the type element 11 in the reverse direction, the polarity of the back EMF sensed by the bridge circuitry 30 is reversed and a negative signal is developed by the differential amplifier 24. This negative signal can pass a rectifier 41 in the impact-sensing circuitry 40 and is of a form shown at 42. This signal 42, being a function of the velocity of the type element 11, parallels the downward spike 63, 64, 65 of FIG. 2.

Control signal 42 is passed through an inverting device 43 to the reset input 59 of the trigger 53 thereby terminating the output on line 54 to terminate the forward or impact drive energization of the motor 15. Also, a positive or up-going signal is generated on the output line 58 of the trigger 53 to thereby activate single shot 57 which develops a time-limited, negative or primary reverse drive signal 56a which is applied through the analog adding device 55 to the input line 21 of the feedback device 22. The time period or length 56b of the signal 56a developed by single shot 57 controls the timing of the point 66 in FIG. 2 where the primary reverse drive energization is terminated. Between points 65 and 66 the velocity control by back EMF is responsive bridge 30, acting through differential amplifier 24 and the feedback device 22, controls the reverse drive of the motor 15 to a constant velocity in a manner similar to the control applied in a forward direction between points 61 and 62.

Upon expiration of the single-shot time period 56b, the reverse drive signal is removed from set point line 21 leaving only the bias applied by bias circuitry 51 to control the feedback device 22. This bias signal will provide for a low-level constant velocity control up to the point where the rocker 13 physically encounters the stop 16 thus arresting the type element 11 in its normal or quiescent position preparatory to a further operation.

The impact signal 42 sensed by impact-sensing circuit 40 has thus been applied to control the printing operation itself by termination of forward drive energy and by application of reverse drive energy. In addition, this signal 42 can be applied to control operation of ancillary printing mechanisms such as an electrically operated escapement mechanism 17 for which

example can be like that disclosed in U.S. Pat. No. 2,905,302. Similarly, the control signal 42 can be applied to control operation of a data input control gate 18 like that employed in the systems disclosed in aforesaid U.S. Pat. Nos. 3,297,124 and 3,417,202 for permitting delivery of new data to the printer for processing.

While a specific illustrative embodiment of our invention has been disclosed herein, it is to be recognized that various additions, deletions, and modifications of the specific details can be made without departing from the novel concepts of our invention. The subject matter sought to be patented thus is described by the following claims.

We claim:

1. A printer having a type-bearing member, a platen member, and means mounting one of said members for relative movement into mutual impact cooperation with the other of said members, wherein the improvement comprises:

a direct-current electric motor for driving said one member into said impact cooperation with said other member, said electric motor generating back EMF, and circuit means for selectively delivering impact driving current to said electric motor and comprising means responsive to a change in polarity of said back EMF induced by said impact cooperation for reversing the direction of current delivered to said electric motor.

2. A printer having a type-bearing member, a platen member, and means mounting one of said members for relative movement into mutual impact cooperation with the other of said members, wherein the improvement comprises:

a direct-current electric motor for driving said one member into said impact cooperation with said other member, said electric motor generating back EMF, and circuit means for selectively delivering impact driving current to said electric motor and comprising means responsive to a change in polarity of said back EMF induced by said impact cooperation for terminating delivery of said impact driving current to said motor.

3. A printer as defined in claim 2 wherein:

said means for delivering current to said motor comprises control means responsive to back EMF produced by said motor for controlling the velocity at which said one member is driven.

4. A printer having a type-bearing member, a platen member, and means mounting one of said members for relative movement into mutual impact cooperation with the other of said members, wherein, the improvement comprises:

an electric motor for driving said one member into said impact cooperation with said other member, means directly responsive to force generated by said impact cooperation for generating a control signal indicative of the instant of said impact cooperation, and printer operation control means for initiating a subsequent printer function in response to said impact-instant-indicative control signal.

5. A printer as defined in claim 4 wherein said printer operation control means comprises means for reversing the direction of current delivered to said motor.

6. A printer as defined in claim 4 wherein said force responsive means comprises electronic circuit means for sensing a change in back EMF produced by said electric motor and electronically emitting said control signal upon occurrence of said change in back EMF.

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