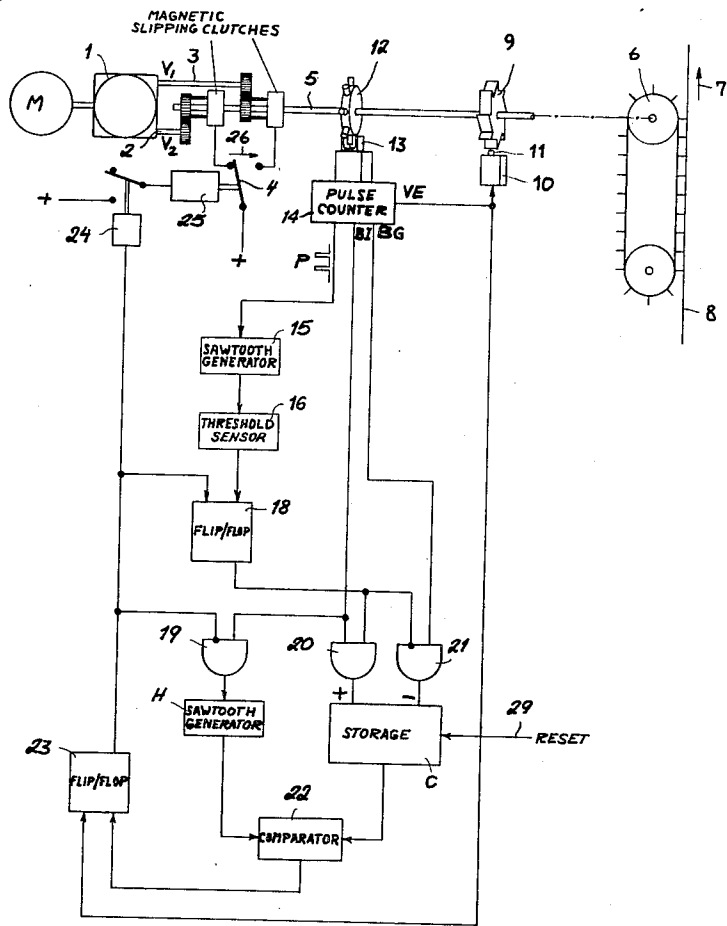


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[54] **TRANSMISSION AND BRAKE FOR STOPPING CONVEYORS**
7 Claims, 2 Drawing Figs.
[52] U.S. Cl. **192/146,**
192/9, 192/142 R, 198/110, 317/140
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146, 148, 142 R; 198/110

ABSTRACT: A drive shaft of an intermittently movable conveyor is alternately entrainable, via respective slipping clutches, by a high-speed and a low-speed input shaft, the switchover to low speed occurring shortly before the arresting of the drive shaft at the end of an operating cycle. A pulse counter excited by the drive shaft measures a braking interval in the final phase of each operating cycle and, at the inception of that interval, triggers a generator of progressively increasing voltage whose output causes the switchover upon reaching a reference value registered in a storage circuit. Depending upon the length of time required for the drive shaft speed to reach its lower limit, the stored reference voltage is either increased or reduced to delay or advance the switchover point to a predetermined instant slightly preceding the end of the cycle.



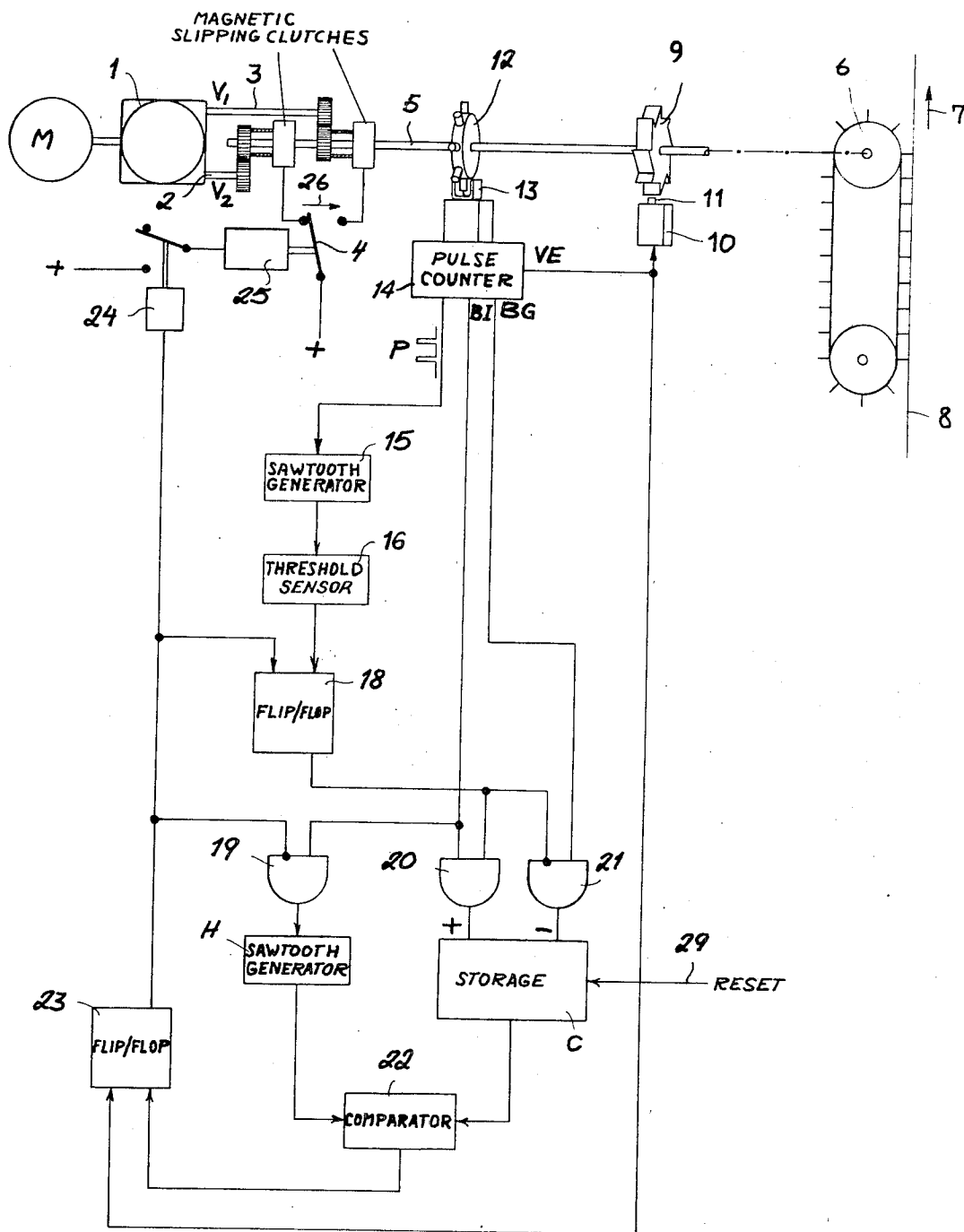


FIG. 1

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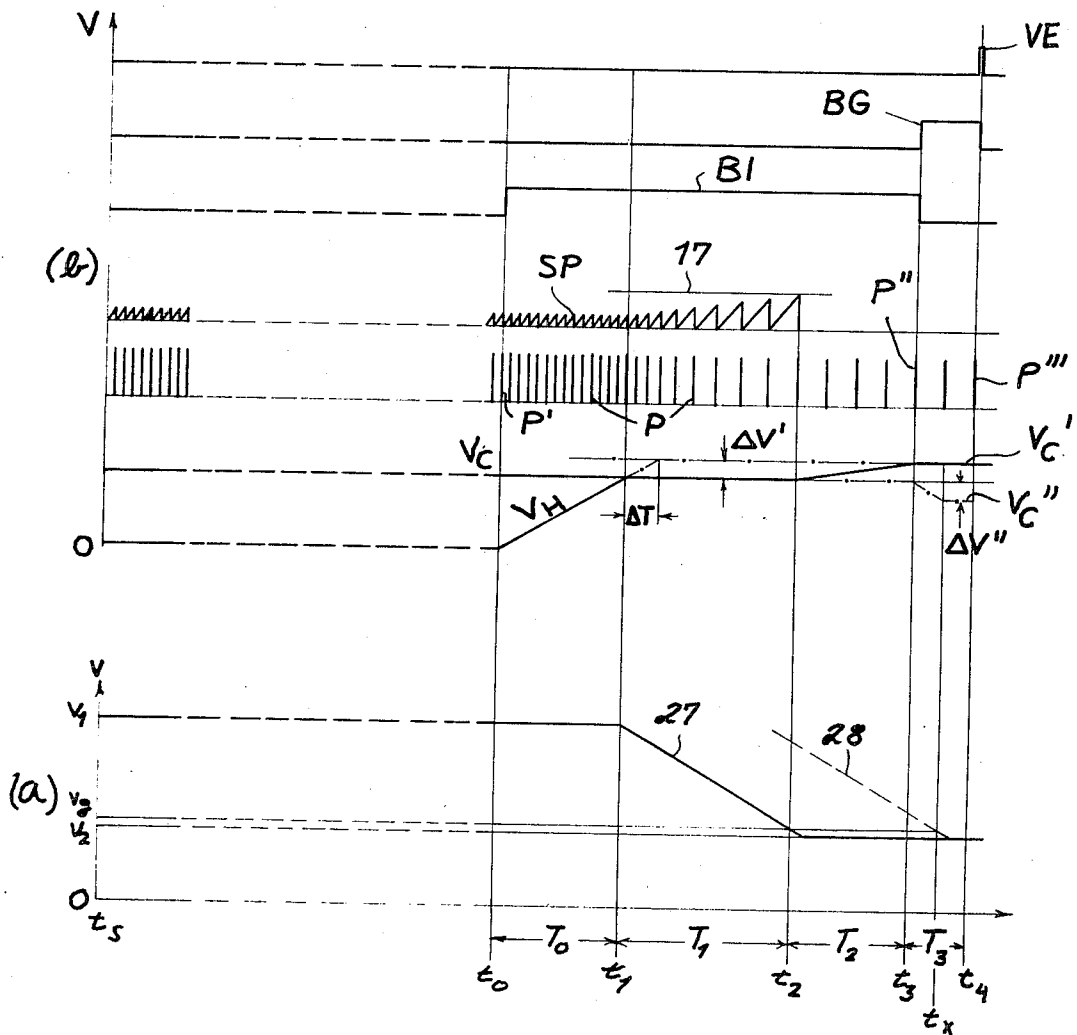


FIG. 2

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TRANSMISSION AND BRAKE FOR STOPPING CONVEYORS

Our present invention relates to a system for intermittently driving a load such as a movable machine part, e.g., a conveyor serving to feed an elongate web or a succession of sheets of paper or the like to a cutter, printer or other processing stage, in repetitive operating cycles each including a high-speed phase and a low-speed phase.

In such a machine it is desirable to operate the conveyor or other machine part at high speed over the major portion of a working cycle and to minimize the impact of stoppage by reducing this speed to a low level just before the machine part is arrested at the end of the cycle. Since, however, the duration of a cycle is subject to variations due to changes in supply voltage or frequency, wear of brake linings, thermal effects and other factors, the instant of arrival of the driven part in its limiting position cannot be predicted with certainty. In practice, with utilization of conventional speed-control devices, the duration of an operating cycle will be subject to relatively slow fluctuations which in the past have necessitated on occasional manual resetting of the controls.

The general object of our present invention is to provide an improved method of and means for so operating a machine of this type that the intermittently movable part thereof is always decelerated at a safe distance from its terminal position but so close to that position that the average operating speed remains high.

A more specific object is to provide a system of this character particularly adapted for the control of an intermittently and unidirectionally rotating drive shaft, e.g., as used to operate a conveyor of a paper-cutting machine.

In accordance with an important aspect of this invention, we measure a predetermined length of travel (e.g., in terms of revolutions of a drive shaft) for the driven member or the load, this length being somewhat less than the total displacement of the load during an operating cycle; the remainder of the cycle, or at least the major portion of the remainder, constitutes a braking interval during which the load speed is progressively reduced from a relatively high level to a relatively low level. At some point during this braking interval, as determined by the comparison of a progressively changing variable (e.g., a voltage) with a reference magnitude, the load is decelerated to a relatively low speed level, preferably by switching its drive from a high-speed input to a low-speed input; after the load has reached its lower speed level, the duration of its movement at that speed to its terminal position (or to a position slightly preceding same) is ascertained and is used to increase or decrease the reference magnitude so as to delay or advance the start of the slowdown in the next cycle in a manner maintaining the end of the deceleration step close to the terminal position, i.e., keeping the time of low-speed travel as short as possible.

If the load is represented by or coupled with a rotatable drive shaft, the length of travel at high speed to an intermediate point and at low speed to a terminal point may be conveniently measured with the aid of path-length-measuring means comprising a pulse counter excited by a pulse generator driven by the shaft. The pulse counter, on reaching a first count denoting the start of the braking interval, emits a signal which, according to a preferred embodiment, triggers speed-sensing means including a generator of a sawtooth voltage whose rising flank (of either polarity) progressively approaches a stored potential until a comparator indicates the equality of the two voltage levels. At that moment the drive shaft, heretofore coupled to a high-speed input shaft for entrainment thereby, is decoupled from that input shaft and is coupled through a slipping clutch to a low-speed input shaft so as gradually to approach the velocity of the latter. Generally, this velocity (or a critical velocity slightly higher than that of the low-speed input shaft) is reached before the counter emits a second signal indicating the end of the braking interval; in this case, the device (e.g., a capacitance) storing the reference potential is further charged during the span between the end

of deceleration and the end of the braking interval so that the magnitude of the reference potential is increased. In the next operating cycle, therefore, the start of deceleration is delayed so as to foreshorten the time of low-speed travel. If, however, the end of deceleration as determined by the comparator output occurs at an instant beyond the braking interval (whose end, therefore, must precede the arrival of the load in its terminal position), the storage device is partly discharged during the period between the end of the braking interval and the reduction of the shaft speed to the critical level so as to lower the reference potential whereby the start of deceleration is advanced in the following cycle. The rates of charge and discharge should be so chosen that the positive or negative increment per cycle of the time elapsed between the start of the braking interval and the beginning of deceleration amounts to only a fraction of that braking interval, the system being thus able to compensate for gradual fluctuations in the length of an operating cycle while maintaining the end of deceleration close to the stopping point.

The above and other features of our present invention will now be described in greater detail with reference to the accompanying drawing in which:

FIG. 1 is a somewhat diagrammatic layout of a control system according to the invention; and

FIG. 2 is a set of graphs relating to the operation of the system of FIG. 1.

As illustrated in FIG. 1, a motor M representing a continuously operable drive means drives via a transmission 1 a pair of shafts 2 and 3, shaft 3 rotating at a high speed v_1 whereas shaft 2 rotates at a considerably lower speed v_2 . Shafts 2 and 3 serve as alternate input members for a driven shaft 5 which can be selectively coupled to either of these input shafts through a switching mechanism 4 including yieldable coupling means shown as a pair of slipping clutches which are alternately operable to accelerate the shaft 5 to speed level v_1 and to decelerate it to speed level v_2 . A machine part to be intermittently advanced, here shown as a conveyor 6, is coupled with shaft 5 for entraining a workpiece 8, such as a paper web, in the direction of an arrow 7. Conveyor 6 may be part of a paper-cutting machine having means for slicing the web 8 whenever the conveyor 6 comes to a halt. For this purpose, the conveyor can be positively arrested by a solenoid 10 which drives a pawl 11 into engagement with a ratchet 9 on shaft 5.

Also mounted on shaft 5 for rotation therewith is a toothed wheel 12 moving in the field of a magnetic pickup head 13 which generates a pulse upon the passage of each tooth. These pulses are delivered to a counter 14 having three outputs BI, BG and VE. The pulses registered in counter 14 are further transmitted to a sawtooth-wave generator 15 where they trigger successive voltage cycles. A speed-sensing means constituted by a threshold sensor 16 compares the stepped voltage from generator 15 with a fixed but preferably adjustable voltage level 17 (see FIG. 2) and, if the flank of any sawtooth rises to that level, energizes the setting input of a bistable timing element or flip-flop 18 whose set output is fed to an input of an AND-gate 20 and in parallel therewith to an inverting input of another AND-gate 21. The second input of AND-gate 20 is connected to the output BI of pulse counter 14, in parallel with an input of a further AND-gate 19 having an inverting second input connected to the set output of another flip-flop 23. The second input of AND-gate 21 is connected to the output BG of pulse counter 14 whose output VE drives the resetting input of flip-flop 23 and, in parallel therewith, the solenoid 10.

The outputs of coincidence gates 20 and 21 are tied to a charging input (+) and a discharging input (-), respectively, of a storage device C which may include a conventional resistance/capacitance network. These two inputs, when energized, cause a gradual and preferably linear change in the output voltage of device C which remains constant if neither of these inputs is energized. A further input 29 serves for a rapid resetting of the device C to zero when manually connected to a voltage source not shown. Charging and discharging along

slightly nonlinear—e.g., exponential—characteristics may be tolerated.

Another sawtooth-voltage generator H is triggerable by an output signal from AND-gate 19 to produce a rising voltage, here assumed to be positive, and to return to zero whenever the input signal disappears. The outputs of generator H and storage device C are applied to opposite inputs of a comparator 22 which delivers an output signal to the setting input of flip-flop 23 as soon as the generator voltage reaches the output potential of unit C. The set output of flip-flop 23, aside from being fed to the inverting input of AND-gate 19 as described above, is also transmitted to the resetting input of flip-flop 18 and to a relay 24 which, when energized, actuates switchover means in the form of a solenoid 25 for reversing the switching mechanism 4 as diagrammatically indicated by an arrow 26.

The operation of the system shown in FIG. 1 will be described with reference to FIG. 2 which shows in graph (a) the velocity v of shaft 5 and in graph (b) the voltages V in the outputs of circuits 14, H and C, all plotted against time t in the course of a complete operating cycle of the system.

For the sake of simplicity it will be assumed that the cycle starts at a time t_s , with shaft 4 rotating at speed v_1 , although in practice it will require a certain length of time to bring this shaft up to the speed of input shaft 3 upon the throwing of switching mechanism 4 into its high-speed position. The rotation of shaft 5 causes the impulse generator 12, 13, forming part of the path-length-measuring means controlled by this shaft, to produce a train of counting pulses P following one another in rapid succession when the shaft speed is high. Generator 15 thus produces a train of sawtooth pulses SP of high frequency but low amplitude, well below the threshold 17 of sensor 16.

Since the cadence of pulses P is proportional to the rotary speed of shaft 5 and therefore to the length of travel of conveyor 6, the attainment of a predetermined pulse count P' signifies the arrival of the load (i.e., web 8) in a predetermined position close enough to the limit of its stroke to allow deceleration of shaft 5 to begin. This pulse count P' occurs at a time t_0 whose distance from starting time t_s may be subject to variation. Time t_0 marks the beginning of a braking interval characterized by the presence of a first signal voltage on counter output BI, as illustrated in FIG. 2(b), during which the switchover from high speed v_1 to a critical speed V_c (slightly exceeding the level v_2) starts at a time t_1 and ends at a time t_2 . The braking interval terminates at a time t_3 with energization of counter output BG by a second signal voltage upon the attainment of a pulse count P''. Shortly thereafter, at a time t_4 , counter output VE is briefly energized upon the occurrence of a count P''' to actuate the solenoid 10 so that shaft 5 is arrested and the cycle ends.

The time interval T_0 between instants t_0 and t_1 depends on the charge stored in circuit C, i.e., on the voltage level V_c applied to the right-hand input of comparator 22. The voltage V_H concurrently applied to the left-hand input of this comparator constitutes a progressively changing variable which rises from zero at instant t_0 and reaches the level V_c at instant t_1 to start a time interval T_1 during which the deceleration of shaft 5 takes place. Thus, the output of comparator 22 sets the flip-flop 23 with consequent blocking of AND-gate 19 to restore the sawtooth generator H to zero, resetting of flip-flop 18 and energization of relay 24 to shift the mechanical switch 25.

As the shaft speed 27 decreases as shown in FIG. 2(a), the spacing of counting pulses P increases, as does the amplitude of sawtooth steps SP. Finally, at time t_2 , threshold sensor 16 responds and sets the flip-flop 18 whereby AND-gate 20 is unblocked in view of the presence of voltage from counter output BI on its other input. This action charges the storage device C to raise its output voltage to a new level $V_{c'}$ during an interval T_2 ending at instant t_3 , i.e., with the deenergization of counter-output BI. Since flip-flop 18 is set, the energization of output BG has no effect upon the blocked AND-gate 21

and does not cause any change in the charge stored in device C.

After the energization of output VE has reset the flip-flop 23 and arrested the shaft 5 against the driving torque of shaft 2 transmitted to it through one of the slipping clutches in coupling 4, a new cycle is begun with self-restoration of counter 14 to zero so that shaft 5 is promptly released by the deenergization of solenoid 10 even as flip-flop 23 returns the coupling mechanism 4 to its high-speed position. In this new cycle, the increased level of reference voltage $V_{c'}$ causes a delay of instant t_1 marking the start of deceleration interval T_1 . This, in turn, reduces the length of time $T_2 + T_3$ during which the conveyor 6 operates at low speed.

If storage circuit C overcharges so that deceleration terminates at an instant t_x within the final period T_3 as indicated at 28 in FIG. 2(a), a flip-flop 18 is not set during the braking interval characterized by the energization of output BI so that AND-gate 21 is opened by the appearance of voltage on output BG and causes a partial discharge of the storage device C whereby the output voltage thereof is lowered as indicated at $V_{c''}$ in FIG. 2(x). Thus, the system tends to maintain the end of the deceleration interval T_1 close to the instant t_3 which coincides with a load position just ahead of the terminal position of its stroke.

If the speed of motor M is changed, the storage circuit C may be discharged via its reset input 29 in order to find its new level consistent with the altered operating conditions. In the first cycle following such discharge, comparator 22 responds immediately to the rising output voltage of generator H so that the braking interval starts substantially at time t_0 . It will be noted that this braking interval has been chosen considerably larger than the time T_1 required for deceleration and that the rate of change of $\Delta V'$ or $\Delta V''$ of reference potential V_c , from one cycle to the other, is relatively small so that the shift ΔT of the deceleration period from its initial position at the beginning of the braking interval toward its ultimate position at the end of that interval will normally occur over a succession of several cycles. This guards against overreaction to changing operating conditions which might endanger the safety of operation.

With a total path length of, say, 11 cm., and with an assumed speed ratio of $v_1:v_2=10:1$, the final slow-motion period T_3 would consume almost half the time available for an entire cycle if the travel path after deceleration were 1 cm. With the present improvement, this final stroke section and the time allotted to it may be considerably reduced, possibly to a value of zero or near-zero.

We claim:

1. A system for intermittently driving a load in repetitive operating cycles, comprising:

a driven member connected with the load to be driven;

continuously operable drive means switchable between a high and a low speed level, said drive means being operatively connected with said driven member and including a yieldable coupling effective at least at said low speed level whereby said driven member is progressively decelerated upon a switching to said low speed level and is arrestable on being entrained at low speed;

switchover means for said drive means having a high-speed and a low-speed position;

path-length-measuring means responsive to the displacement of said driven member for emitting a first signal upon the attainment of a predetermined intermediate point of a working stroke and for emitting a second signal upon the approach of a terminal point of said working stroke;

generator means effective in the high-speed position of said switchover means and controlled by said path-length-measuring means for starting the generation of a progressively changing variable upon the occurrence of said first signal;

a source of a reference magnitude for said variable;

comparator means connected to said generator means and to said source for determining the arrival of said variable at a value bearing a predetermined relationship with said reference magnitude, said comparator means on ascertaining said relationship providing an output signal controlling said switchover means for changing same to said low-speed position whereby said driven member is subjected to progressive deceleration;

speed-sensing means controlled by said driven member for determining the arrival thereof at a critical speed close to said low speed level;

timing means jointly controlled by said speed-sensing means and said path-length-measuring means for determining the relative time position of the instant of arrival at said critical speed and the emission of said second signal, said source being responsive to said timing means for altering said reference magnitude in a sense shifting the point of change of said switchover means during a subsequent operating cycle to terminate the deceleration of said driven member at an instant closer to the emission of said second signal;

and stop means controlled by said path-length-measuring means for momentarily arresting said driven member upon its arrival at said terminal point and for restoring said switchover means to said high-speed position.

2. A system as defined in claim 1 wherein said path-length-measuring means comprises a pulse generator and a pulse counter receiving the output of said pulse generator.

3. A system as defined in claim 2 wherein said driven member is a shaft, said pulse generator including a toothed

wheel on said shaft and electromagnetic pick up means adjacent said wheel.

4. A system as defined in claim 2 wherein said speed-sensing means comprises a sawtooth-voltage generator triggerable by the output of said pulse generator and threshold means for comparing the output of said sawtooth-voltage generator with a predetermined amplitude level.

5. A system as defined in claim 1 wherein said generator means comprises a voltage generator with a substantially linearly varying output voltage, said source being a storage circuit for an electrical charge.

6. A system as defined in claim 5 wherein said timing means comprises a bistable element settable by said speed-sensing means and resettable by said comparator means, a first coincidence circuit jointly controlled by said bistable element and said path-length-measuring means for causing a progressive increase in the charge of said storage circuit during a period beginning with said output signal and ending with said second signal, upon said output signal preceding said second signal, and a second coincidence circuit jointly controlled by said bistable element and by said path-length-measuring means for causing a progressive decrease in said charge during a period beginning with said second signal and ending with said output signal, upon said second signal preceding said output signal.

7. A system as defined in claim 6 wherein said first and second coincidence circuits comprise a pair of AND-gates with respective inputs connected in parallel to an output of said bistable element, one of said inputs including an inverter.

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