

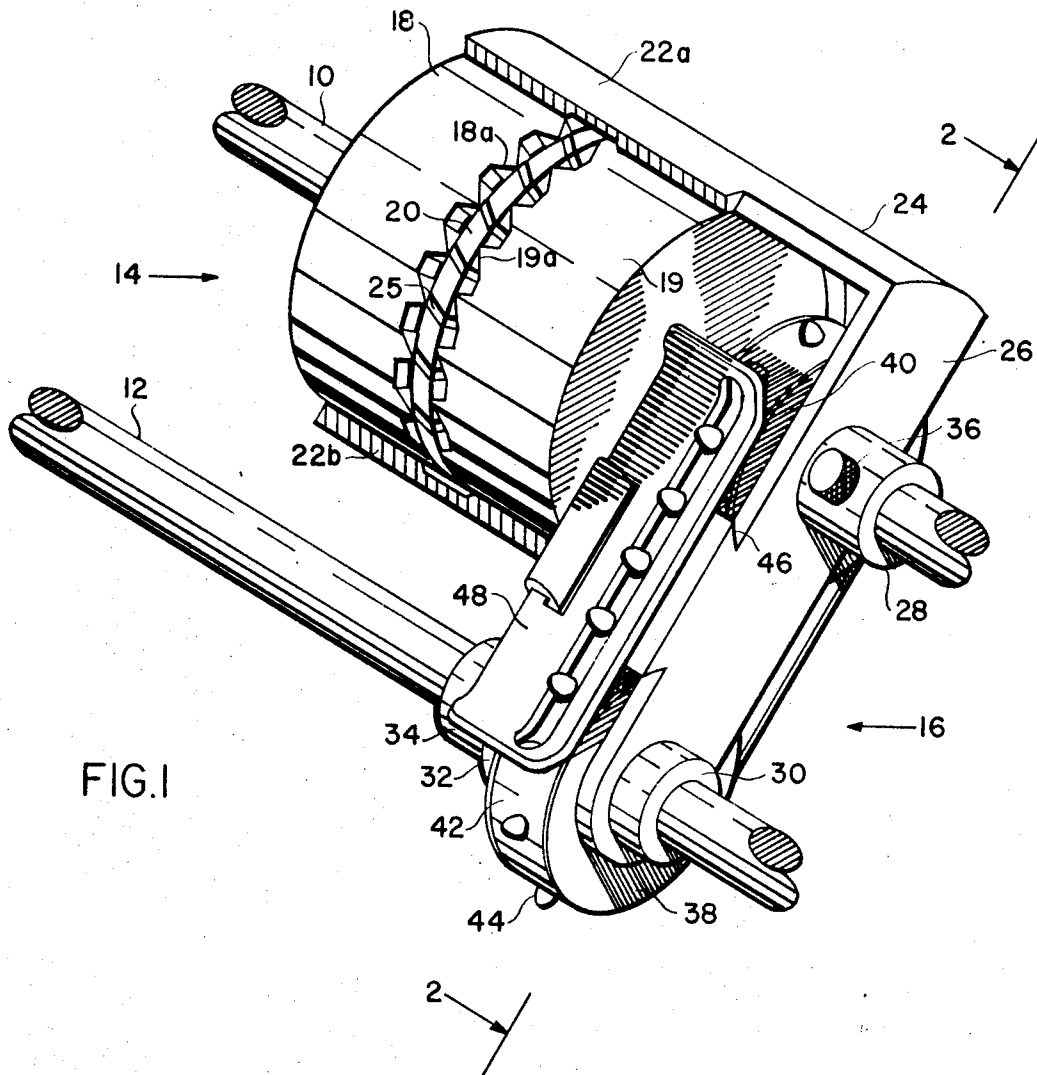
Aug. 4, 1970

A. NYMAN
INCREMENTING DEVICE

3,522,501

Filed Jan. 4, 1968

4 Sheets-Sheet 1



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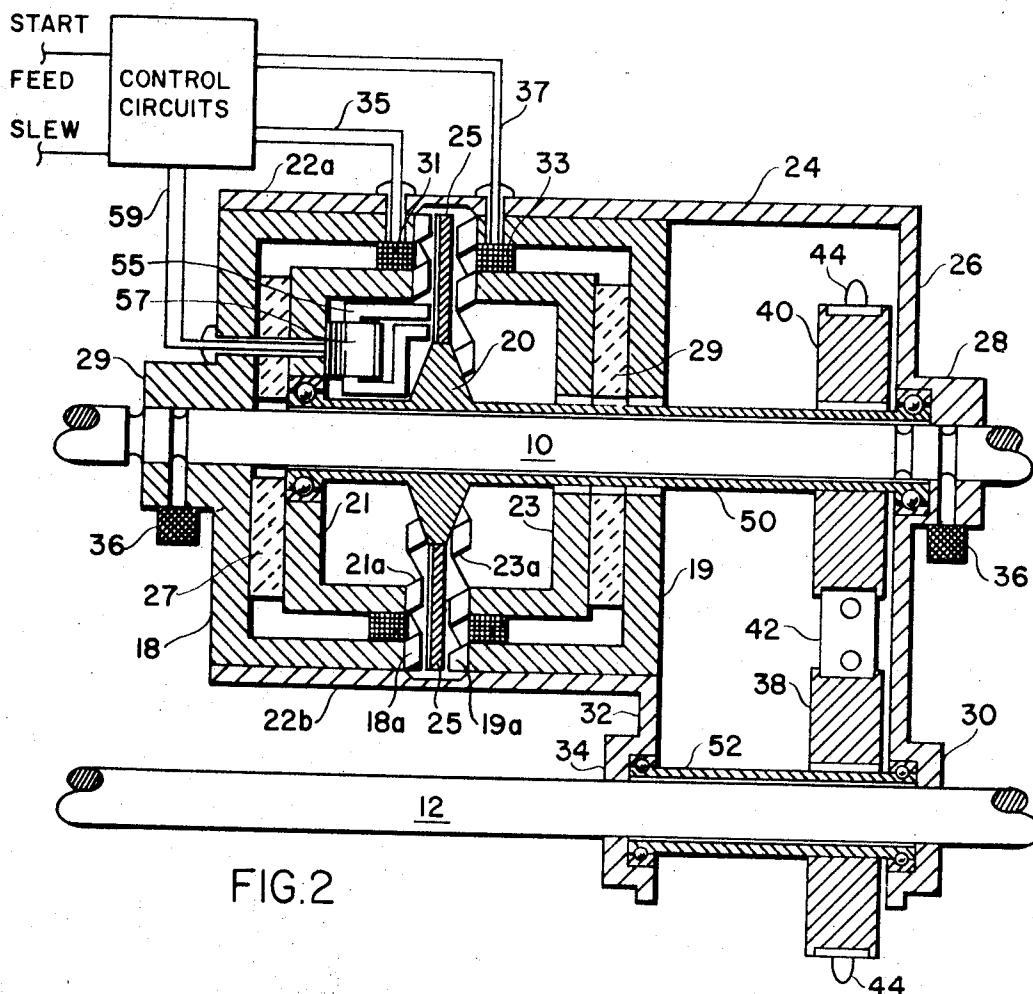


FIG. 2

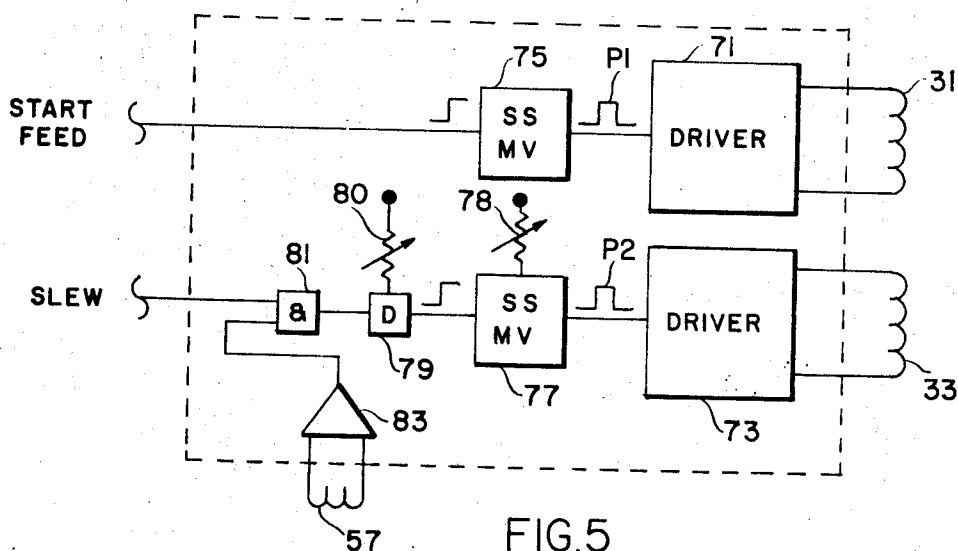


FIG. 5

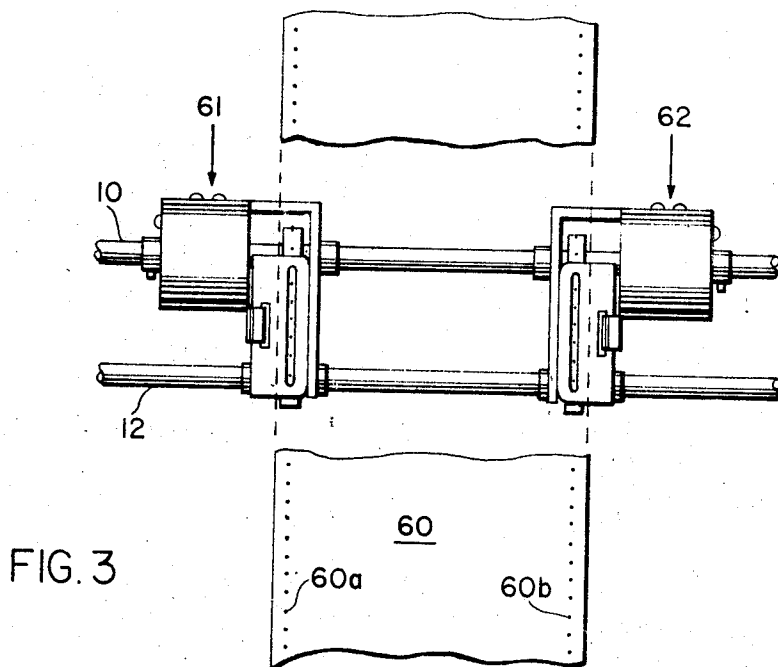
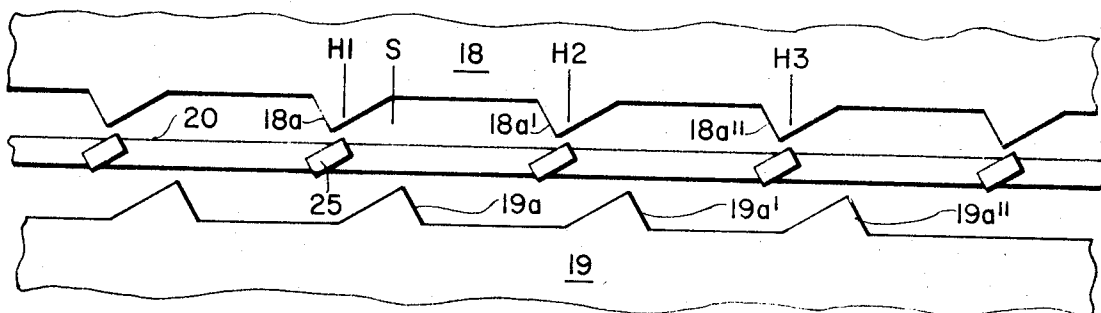
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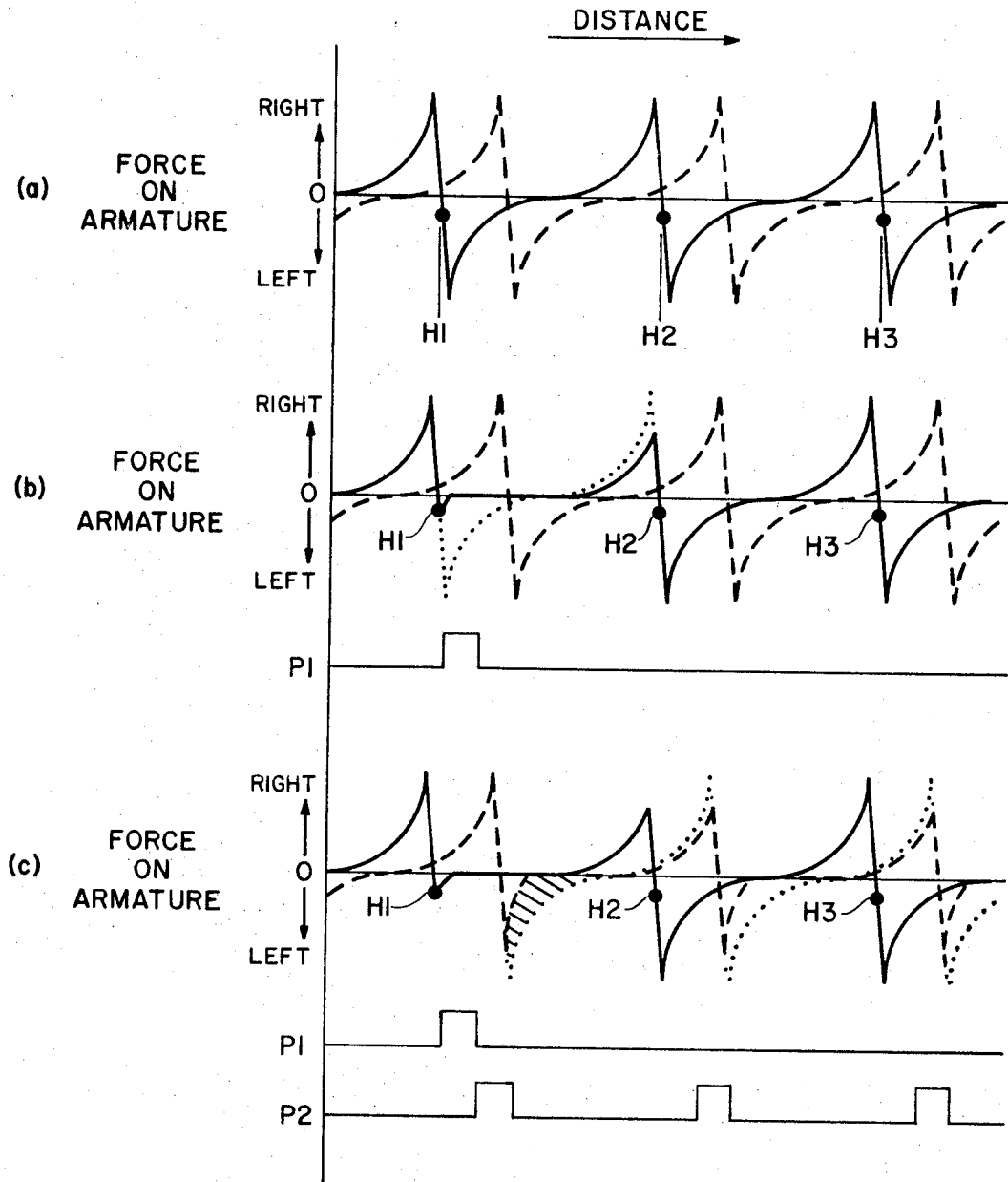


FIG.6

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3,522,501

INCREMENTING DEVICE

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10 Claims

ABSTRACT OF THE DISCLOSURE

Each of a plurality of paper feed tractors adapted to engage edge perforations in a web of forms for feeding thereof is connected to a compact incrementing motor device which is operable in a stepping mode for feeding the forms line-by-line or in a slewing mode for feeding the forms continuously. Each incrementing motor comprises a set of radially spaced holding pole teeth connected to a first permanent magnet and a set of radially spaced drive pole teeth connected to a second permanent magnet. The two sets of pole teeth are mounted in opposed, offset relation to one another and an armature containing a plurality of radially spaced ferrous segments is rotatably mounted between the sets of teeth and connected to the drive sprocket of the paper feed tractor. A bucking coil is provided in association with each of the sets of pole teeth and a control circuit operates to pulse the coils in selected patterns to either step the armature or rotate it continuously.

BACKGROUND OF THE INVENTION

This invention relates to incrementing motor devices and, more particularly, to incrementing motor devices useable for driving the paper form feeding mechanism of a high speed line printer in either a step feeding mode or a continuous feeding mode.

In high speed line printing it is common to feed the print medium, e.g., an edge-perforated paper web, step-by-step past the print line by employing one or two pairs of laterally spaced feed tractors which engage the edge perforations in the form. The tractors are mounted on a common drive shaft which is in turn connected by means of a drive train usually in the form of a belt or chain to an external clutch-brake system. The clutch-brake supplies the required start-stop intermittent angular motion to the drive shaft to feed the print medium in the desired incremental fashion.

Since a single drive source and clutch-brake is generally employed to drive all the feed tractors it is of necessity a relatively massive unit having a high degree of power consumption and noise output. Also, the necessity for an intermediate drive train tends to introduce serious inaccuracies in the system particularly at high stepping rates due to oscillation and slippage present in the drive train.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an important object of the invention to provide an improved incrementing device particularly adapted for use in feeding forms for high speed printing, which device eliminates the aforementioned deficiencies inherent in prior art systems.

Another object is to provide an improved high-speed incrementing device capable of operating with a high degree of accuracy and with a very low degree of power consumption in either a stepping mode or a slewing (continuous) mode.

Still another object is to provide an improved high speed incrementing device having a highly compact construction to enable mounting in direct connection with a form feeding sprocket of a high speed line printer.

Still another object is to provide a high speed incre-

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menting device operable without physical impact between parts, thereby eliminating much of the noise associated with clutch-brake mechanism and other forms of incrementing devices.

In accordance with a first aspect of the invention, a set of magnetic holding poles is employed to define the desired incrementing positions and a moveable armature having at least one magnetically-attractable segment positioned adjacent to the poles is adapted to be held in any given incrementing position by the holding pole corresponding to the selected position. A set of magnetic drive poles is arranged adjacent to the armature such that when the force of the holding poles is removed or reduced the drive poles exert a drive force on the segment to move the armature into alignment with the next holding pole.

In accordance with another aspect of the invention the holding and drive poles comprise permanent magnet assemblies and the means for removing or reducing the holding force includes a bucking coil mounted in the area of the holding poles so as to enable selective generation of a flux field to counteract that from the holding pole magnet.

In accordance with still another aspect of the invention, means are provided for removing or reducing the drive force exerted on the armature by the drive poles at a time when that force is normally operating to brake the armature whereby the inertia of the armature acts to carry it past the next adjacent holding pole, thus providing the device with a capability for imparting sustained movement to the armature. This feature provides for paper slewing such as is commonly required in any high speed line printing operation.

These and other objects, features and advantages will be made apparent by the following detailed description of a preferred embodiment of the invention. The description being supplemented by drawings as follows:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the incrementing device of a preferred embodiment of the invention operating in conjunction with a paper feed sprocket.

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1 illustrating the detailed relationship between the elements of the mechanism.

FIG. 3 is a plan view showing a pair of incrementing mechanisms mounted to feed a perforated paper form.

FIG. 4 is schematic diagram illustrating, in detail, the relationship between the magnetic holding poles, drive poles, and armature of the incrementing device of the preferred embodiment.

FIG. 5 is a schematic diagram of a control circuit for effecting the various modes of operation of the invention.

FIGS. 6a, 6b and 6c are diagrams illustrating the forces exerted by the holding poles and drive poles on the armature as the latter moves through its various modes of operation.

DETAILED DESCRIPTION

Referring to FIG. 1, an incrementing device in accordance with the invention as adapted to feed paper forms through, for example, a high speed line printer, is hereinafter described. The unit is mounted for operation on a pair of stationary mounting shafts 10 and 12. These shafts, may, for example, be supported between the stationary side frames of the machine. The drive portion 14 of the device comprises a magnetic holding pole assembly 18 and a magnetic drive pole assembly 19 stationarily mounted on shaft 10 and connected together by an outer casing 22, preferably constructed of a nonmagnetic material such as aluminum or brass. The holding pole assembly 18 has a plurality of individual teeth or holding poles 18a disposed around its right-hand edge. The drive

pole assembly 19 has an equal plurality of individual teeth or drive poles 19a disposed about its left-hand edge. The holding poles and drive poles cooperate, in a manner to be described in detail subsequently, with a rotatable armature 20 which supports a plurality of radially oriented segments or blades 25 constructed of a magnetically-attractable material such as soft iron.

The paper feed portion 16 of the unit is supported from the casing 22 and includes a pair of spaced frames members 26 and 32, the former of which is connected to an arm 24 extending from the upper portion 22a of the casing. These frame members are supported on the mounting shafts 10 and 12 by the collars 28, 30, and 34. A drive wheel 40 is journaled within the unit for rotation about shaft 10 and is drivably connected to the armature 20 also rotatable about shaft 10. An idler wheel 38 is journaled in collars 30 and 34 for rotation about shaft 12. A sprocket belt 42 is supported by the wheels 38 and 40 and carries a set of spaced sprocket pins 44 adapted to engage the edge perforations in a conventional record medium. A backup member 46 extends from frame 26 between the wheels 38 and 40 and resides beneath the belt 42 to provide a solid support therefor. A spring-load hinged pressure plate 48 is adapted to fit over the top of the upper run of belt 42 and is slotted in a conventional manner to prevent the record medium from riding off the sprocket pins 44 as drive wheel 40 rotates to feed the medium. A manually operable detent pin 36 is adjustably secured in collar 28 either through threading or spring loading to enable positioning of the unit at selected lateral positions on the mounting shafts. As shown in FIG. 2, a similar detent may be included on the left-hand collar 29 projecting from the magnetic holding pole assembly 18.

FIG. 3 illustrates the manner in which a pair of incrementing devices 61 and 62 may be positioned on the mounting shafts 10 and 12 for feeding an edge perforated record web 60. The left-hand unit 61 engages the left-hand perforations 60a while the right-hand unit 62 engages the right-hand perforations 60b. While the configuration depicted in FIG. 3 generally conforms to that usually employed for feeding a document for high-speed line printing, it is readily apparent that the arrangement of FIG. 3 is also applicable in any system calling for longitudinal feeding of perforated sheets or webs of indeterminable lengths.

Referring now to FIG. 2, which is a sectional view taken through the unit of FIG. 1, the detailed relationship of the various elements of the preferred embodiment is hereinafter described. As therein shown, the holding pole magnetic assembly 18 comprises a cup-shaped pole piece 18 constructed of a magnetically-attractable material such as soft iron stationarily mounted on shaft 10 by a collar 29 and detent 36. The holding pole assembly further comprises an inner cup-shaped pole piece 21 also constructed of magnetically-attractable material such as soft iron. Pole piece 21 is fixed by suitable non-magnetic fastening means to pole piece 18 so that no relative movement is permitted therebetween. Mounted between the pole pieces 18 and 21 is an annular permanent magnet 27 constructed of, for example, any of the various well known ceramic magnetic materials magnetized in the axial direction, i.e., the opposite poles being on the flat side surfaces of the annulus.

As previously, discussed the pole teeth 18a of pole piece 18 are distributed about the lip portion thereof, i.e., the right-hand edge of the pole piece, in an equally spaced manner. Pole piece 21 has a like number of similar pole teeth 21a distributed about its right-hand edge in radial alignment with the teeth 18a. A bucking coil 31 is positioned between the pole pieces 18 and 21 in a location as near the teeth 18a and 21a as possible. The coil 31 is electrically connected via leads 35 to external circuitry described subsequently.

The drive magnet assembly includes a pair of cup-shaped pole pieces 19 and 23 constructed in the same general manner as the pole pieces 18 and 21. However, the

pole teeth 19a and 23a positioned on the left-hand edges of the pole pieces, while being spaced at increments identical to those separating the holding pole teeth 18a and 21a, are circumferentially offset from the latter teeth and are also shaped differently than those teeth. The details of this spacing and shaping are discussed in more detail subsequently in connection with FIG. 4. An annular permanent magnet 29, identical in construction to the magnet 27, is positioned between the pole pieces 19 and 23. As in the case of the latter pair of pole pieces, this arrangement sets up a magnetic field across the pole teeth 19a and 23a.

The armature 20 is connected to a rotatable drive shaft 50 which is journaled between pole piece 21 on the left and frame 26 on the right. Both the armature 20 and the shaft 50 are constructed of a light weight, nonmagnetic material such as aluminum. The armature supports a plurality of segments or blades 25 radially distributed about the armature. There is one segment 25 for each of the sets of pole teeth 21a-18a. The feed wheel 40 is keyed to shaft 50 and is thus adapted to be rotatably driven by the armature. The idler wheel 38 is keyed to a rotatable axle shaft 52 which is journaled in bearings supported on the left by frame 32 and on the right by frame 26. The wheel 38 is keyed to the shaft 52. For control purposes to be described subsequently, a sensing transducer 55 having a sensing coil 57 electrically connected to the control circuits via leads 59 is stationarily mounted in the space between pole piece 21 and armature 20. The transducer 55 senses the passage of each segment 25 and generates an output pulse on leads 59 in response thereto.

The relationship between the holding poles, the drive poles and the armature and armature segments 25 is illustrated in the diagram of FIG. 4 which is a development of a portion of the outer periphery of the incrementing unit as shown in FIG. 1. As seen in FIG. 4, the holding pole teeth 18a are equally spaced from one another as are the drive poles teeth 19a. The drive teeth, however, are offset from the holding teeth for purposes discussed in the following description of operation. Each of the teeth 18a is triangular in shape with the leading (left-hand) edge having a greater slope than the trailing (right-hand) edge. It has been determined that optimum operation of the device is achieved when the slope of the leading edge of these teeth is about 60 degrees inclined to the direction of motion of the armature 20 (to the right in FIG. 4) and when the trailing edge is inclined approximately 30 degrees thereto. The drive teeth 19a also preferably have a 30 degree-60 degree relationship to the direction of armature travel except that in the case of the drive teeth the relationship is reversed, i.e., the leading edge has a thirty degree slope and the trailing edge has a sixty-degree slope.

The armature segments 25 are rectangular in cross section and are mounted at approximately a 30-degree incline with respect to the direction of armature travel. It is to be understood that these specific shapes and orientations of the pole teeth and armature segments are given herein since they are believed to constitute a somewhat optimum arrangement. It is entirely conceivable that other different geometric configurations of these elements could achieve operational results in accordance with the principals of the invention.

Referring now to FIG. 5, the control circuit depicted generally in FIG. 2 is hereinafter described in detail. The bucking coil 31 associated with the holding poles 18a-21a is adapted to be selectively energized by a current driver circuit 71 which is in turn controlled by a single-shot multivibrator 75. A positive-going transition on the START-FEED input line triggers single-shot 75 and causes a predetermined duration voltage pulse P1 to be generated at its output. This causes a predetermined current pulse to be transmitted to coil 31, setting up a temporary magnetic field which opposes that generated across the pole teeth 18a-21a by permanent magnet 27. The

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temporary counteracting field from coil 31 therefore has a bucking effect and removes or at least substantially diminishes the strength of the field at the holding poles. After single-shot 75 times out, driver 71 is deenergized and the current pulse through coil 31 terminates, allowing the permanent magnet field at the holding poles to restore.

The bucking coil 33 associated with drive teeth 19a-23a is energized by a current driver circuit 73 which in turn is controlled by a single-shot multivibrator 77. A potentiometer 78 is connected in circuit with single-shot 77 to enable manual adjustment of the timeout period of the single-shot. That is to say, while the amplitude of the single-shot output pulse P2 is fixed, the adjustment potentiometer 78 is provided to vary the duration of the signal for purposes explained below in the description of operation. A logical AND circuit 81 receives one input from the SLEW input control line and receives its other input from the output of amplifier 83 connected to sensing coil 57 of the segment sensing transducer 55. Any time the SLEW input line is positive, AND 81 generates a positive signal each time an armature segment 25 passes transducer 55. The output from AND 81 is fed to a delay circuit 79 having an adjustment potentiometer 81 to enable a manual variation of the delay period of the delay circuit. Following the period of delay introduced by circuit 79 a positive signal is fed to the input of single-shot 77 to cause energization of coil 33. As in the case discussed above for coil 31, coil 33 when energized generates a magnetic field which opposes the field set up across teeth 19a-23a by permanent magnet 29. This counteracting field thus removes or at least substantially diminishes the field at the drive teeth. When single-shot 77 times out and its output P2 returns to negative, the current from driver 73 ceases and the field due to magnet 29 is restored at the drive teeth.

OPERATION

With reference now to FIGS. 2, 4, and 6, operation of the preferred embodiment of the invention is hereinafter described. FIG. 6a shows the forces which would be exerted on armature 20 if it were rotated (moved to the right in FIG. 4) by an external force past the holding and drive pole teeth. The abscissa denotes distance and the ordinate denotes force, rightward (in the sense of FIG. 4) force on the armature being represented by those portions of the curves above the abscissa and leftward force being represented by those portions of the curves extending below the abscissa. The positions H1, H2, and H3 shown in FIGS. 6a, b, and c correspond to the holding teeth H1, H2 and H3 shown in FIG. 4. The solid curves in FIG. 6 represent the force exerted on the armature by the holding teeth and the dashed curves represent the force exerted on the armature by the drive teeth.

Thus, taking FIGS. 6a and 4 together, when the indicated armature segment 25 is aligned with position H1, it, as well as all the other segments on the armature, is firmly held in a fixed position slightly to the right of holding tooth 18a since the leftward force exerted on the segment by tooth 18a is equal the rightward force exerted on the segment by the drive tooth 19a. Any external forces which would tend to move segment 25 either to the left or right from position H1 are opposed by the strong counteracting forces generated by holding tooth 18a. Thus, the combined effect of all the holding teeth acting on the respective armature segments firmly locks the armature in a fixed position.

FIG. 6b illustrates the operation involved in incrementing the armature 20 one tooth interval to the right. A START FEED signal is presented to the input of single-shot 75 (FIG. 5) which thereupon generates the output signal P1 for energizing bucking coil 31. The effects of this bucking pulse are shown in FIG. 6b where the force from holding tooth 18a is reduced substantially to zero and remains at 0 for the duration indicated by the

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solid curve. Thus, when the holding field disappears segment 25 experiences a rightward imbalance of force due to the field still emanating from drive tooth 19a and thus the armature is accelerated in the rightward direction. As the segment approaches tooth 19a, the armature gains sufficient inertia to overshoot the drive tooth. When this occurs the drive teeth exert a leftward or braking force on the armature which slows it down. However, as segment 25 approaches holding tooth 18a' the holding field begins to restore and a rightward force is again exerted on the armature. By the time segment 25 reaches position H2 the holding force has been fully restored and since the inertia of the armature has been considerably reduced by the braking effect exerted by the drive teeth, segment 25 is captured by the holding force exerted by tooth 18a', as, of course, is also the case with each of the other segments and their respective holding teeth. The armature is thus arrested and firmly locked with segment 25 in position H2. Of course, each additional START FEED signal presented to the control circuit causes the armature to advance an additional pole interval in the rightward direction. Each such increment of advance is, of course, imparted to drive wheel 40 (FIG. 2) by shaft 50 thereby causing the advance of the record medium one line space for each increment of advance.

The operation associated with slewing (continuous feeding) the record medium is shown in FIG. 6c. Again, the initial condition assumes that segment 25 (FIG. 4) is held captive by pole 18a. As before, the feed operation is initiated by a START FEED command which generates a pulse P1 to remove the holding field. As before, armature 20 is accelerated to the right by the action of drive tooth 19a on segment 25 and by the action of the other drive teeth on their corresponding armature segments. However, since a slewing operation has been commanded, the SLEW input line to the control circuit (FIG. 5) is positive. When segment 25 reaches a position indicated by S in FIG. 4, sensing coil 57 and amplifier 83 generate a positive pulse which is gated to the input of delay circuit 79 by AND 81. After the period of delay introduced by circuit 79, single-shot 77 is triggered to generate a P2 pulse whereby bucking coil 33 is energized by driver 73. This removes the drive field just after segment 25 passes drive tooth 19a as shown by the dashed line in FIG. 6c. The dotted line indicates the normal non-diminished drive force. Thus, due to the removal of the drive field, the armature experiences a lesser degree of braking as segment 25 progresses from tooth 19a toward tooth 18a', and the armature therefore approaches the latter tooth with a higher velocity and a greater amount of inertia. This added inertia is sufficient to carry segment 25 past tooth 18a'. After this occurs the drive field which has restored to its normal value following the first P2 pulse again accelerates the armature to the right so that segment 25 overshoots drive tooth 19a' and progresses toward the next holding tooth 18a''. Since the slew command is still active a second P2 pulse is generated and again the normal braking effect of the drive tooth is removed. This preserves the inertia of the armature so that it overshoots holding tooth 18a'' and is again accelerated, this time by drive tooth 19a''.

So long as the slew command remains, the transducer 25 causes the pulses P2 to be generated whereby the slewing action is sustained. As soon as the slew command is discontinued, the drive teeth once again exert the full degree of braking on the armature so that the armature is arrested and held in a fixed position opposite the holding teeth.

A negative feedback effect is inherent in the operation of the slewing control. This effect tends to stabilize the slewing velocity imparted to the drive wheel 40. This negative feedback effect operates as follows. The delay imposed by circuit 79 is of a fixed, predetermined duration so that as an armature segment passes the position

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S (FIG. 4) the leftward braking force generated by the drive teeth is depicted by the dotted curve shown in FIG. 6c. After the fixed period of delay the force diminishes to the level depicted by the dashed portion of the curve. The force curve actually applied to the armature will lie somewhere in the crosshatched area shown in FIG. 6c, depending on the velocity of the armature. Thus, if the armature is travelling faster than its nominal velocity it experiences something near the full braking action of the drive teeth (dotted curve) and is decelerated to a greater degree. If the armature is travelling at a velocity below nominal it experiences a lesser braking effect (dashed curve), and is not decelerated as much. This negative feedback effect thus tends to maintain a constant slewing velocity. The slewing velocity is controllable within a given range by adjusting the potentiometers 78 and 80 (FIG. 5) to vary the period of energization of degaussing coil 33 and the period of delay of circuit 79.

Of course, various combinations of the pulses P1 and P2 may be used to control the slewing torque generated on the armature. For example, means may be provided for retriggering single-shot 75 from the output of AND 81 to produce a succession of P1 pulses, as well as P2 pulses, during slewing. Suitable delay means must be interposed between the output of AND 81 and the input of single-shot 75 in this arrangement so that each P1 pulse after the first will act to diminish the holding field just at the instant that the armature segments are passing the holding pole teeth. This will reduce the braking effect that the holding field would normally have on the armature and thus will increase the torque applied thereto. This enables higher slewing velocity and/or increases the paper pulling capacity of the system.

It will be appreciated that the above and other changes in the form and details of the above described preferred embodiment may be effected by persons of ordinary skill without departing from the true spirit and scope of the invention.

What is claimed is:

1. An incrementing device comprising:

- (a) an armature having at least one segment of magnetically-attractable material constrained to move along a line;
- (b) a set of magnetic holding poles mounted adjacent said armature on one side of the line, the holding poles being adapted to exert a holding force on said segment when said segment is aligned with an initial one of said poles;
- (c) a set of magnetic drive poles mounted adjacent said armature on the opposite side of said line from said holding poles, said drive poles being adapted to exert a drive force on said segment in the direction of said line when said segment is aligned with said initial holding pole; and
- (d) means for diminishing said holding force to permit said drive force to move said segment along said line.

2. The device as recited in claim 1 wherein said holding poles and said drive poles are spaced at equal intervals along said line, and wherein said drive poles are offset from said holding poles.

3. The device as recited in claim 1 and further including:

- (a) a first permanent magnet connected to said holding poles for generating said holding force; and
- (b) a second permanent magnet connected to said drive poles for generating said drive force;

and wherein said diminishing means comprises:

- (a) a conducting coil mounted adjacent said holding poles; and
- (b) means for energizing said coil with a current to set up a magnetic field opposing the field of the first permanent magnet.

4. The device as recited in claim 2 wherein said drive

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force imparts an inertia to said segment sufficient to cause said segment to overshoot the first one of said drive poles it comes to and wherein said diminishing means is adapted to restore said holding force after said segment passes said first drive pole, whereby said segment is drawn into alignment and held by the next holding pole.

5. The device as recited in claim 4 and further comprising: means for diminishing said drive force after said segment passes said first drive pole, whereby sufficient inertia is retained by said segment to cause said segment to overshoot said next holding pole.

6. The device as recited in claim 5 and further including: a permanent magnet connected to said drive poles for generating said drive force, and wherein said drive force diminishing means comprises:

- (a) a conducting coil mounted adjacent said drive poles; and
- (b) means for energizing said coil with a current to set up a magnetic field opposing the field of said permanent magnet connected to said drive poles.

7. The device as recited in claim 6 wherein said energizing means comprises:

- (a) sensing means for generating an output signal when said segment reaches a predetermined position; and
- (b) means responsive to said output signal for transmitting said energizing current to said coil.

8. An incrementing device comprising:

- (a) a rotatable armature having a plurality of radially oriented segments of magnetically-attractable material;
- (b) a holding magnet having a plurality of holding poles, one for each said armature segment, positioned on one side of said armature, each said pole being adapted to exert a holding force on one of said segments to hold said armature in a fixed position.
- (c) a drive magnet having a plurality of drive poles, one for each said armature segment, positioned on the other side of said armature, said poles being constructed and arranged to exert a drive torque on said armature when said armature is in said fixed position; and
- (d) means for diminishing said holding force to permit said drive torque to rotate said armature.

9. The device as recited in claim 8 wherein said holding magnet comprises:

- (a) an inner pole piece with a cylindrical lip having a plurality of triangularly shaped teeth on its edge, each tooth having, with respect to the direction of rotation of said armature, a leading edge of greater slope than the trailing edge;
- (b) an outer pole piece with a cylindrical lip having one tooth on its edge for each of the teeth on said inner pole piece, each tooth on the outer pole piece being substantially identical to the teeth on the inner pole piece, each pair of outer and inner pole piece teeth forming one of said holding poles; and
- (c) an annular magnet positioned between said inner and outer pole pieces.

10. The device as recited in claim 8 wherein said drive magnet comprises:

- (a) an inner pole piece with a cylindrical lip having a plurality of triangularly shaped teeth on its edge, each tooth having, with respect to the direction of rotation of said armature, a leading edge of lesser slope than the trailing edge;
- (b) an outer pole piece with a cylindrical lip having one tooth on its edge for each of the teeth on said inner pole piece, each tooth on the outer pole piece being substantially identical to the teeth on the inner pole piece, each pair of outer and inner pole piece teeth forming one of said holding poles; and
- (c) an annular magnet positioned between said inner and outer pole pieces.

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