

Zenner et al.

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[54] CARRIAGE DRIVE FOR HIGH SPEED
PRINTER

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[52] U.S. Cl.....197/64, 197/68, 197/82,
192/41 S, 74/220, 74/405

[51] Int. Cl. B41j 19/02

[58] **Field of Search**.....197/60, 62, 64, 65, 66, 68,
197/70, 89, 91, 183, 93, 82; 192/41 S, .096; 74/220,
405

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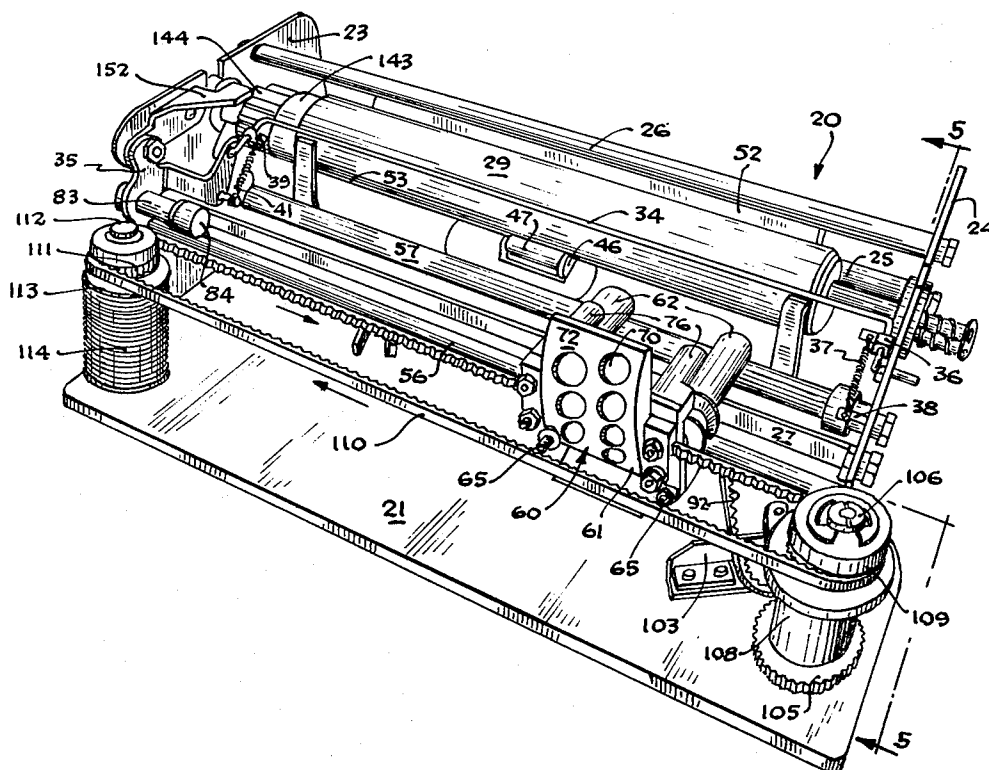
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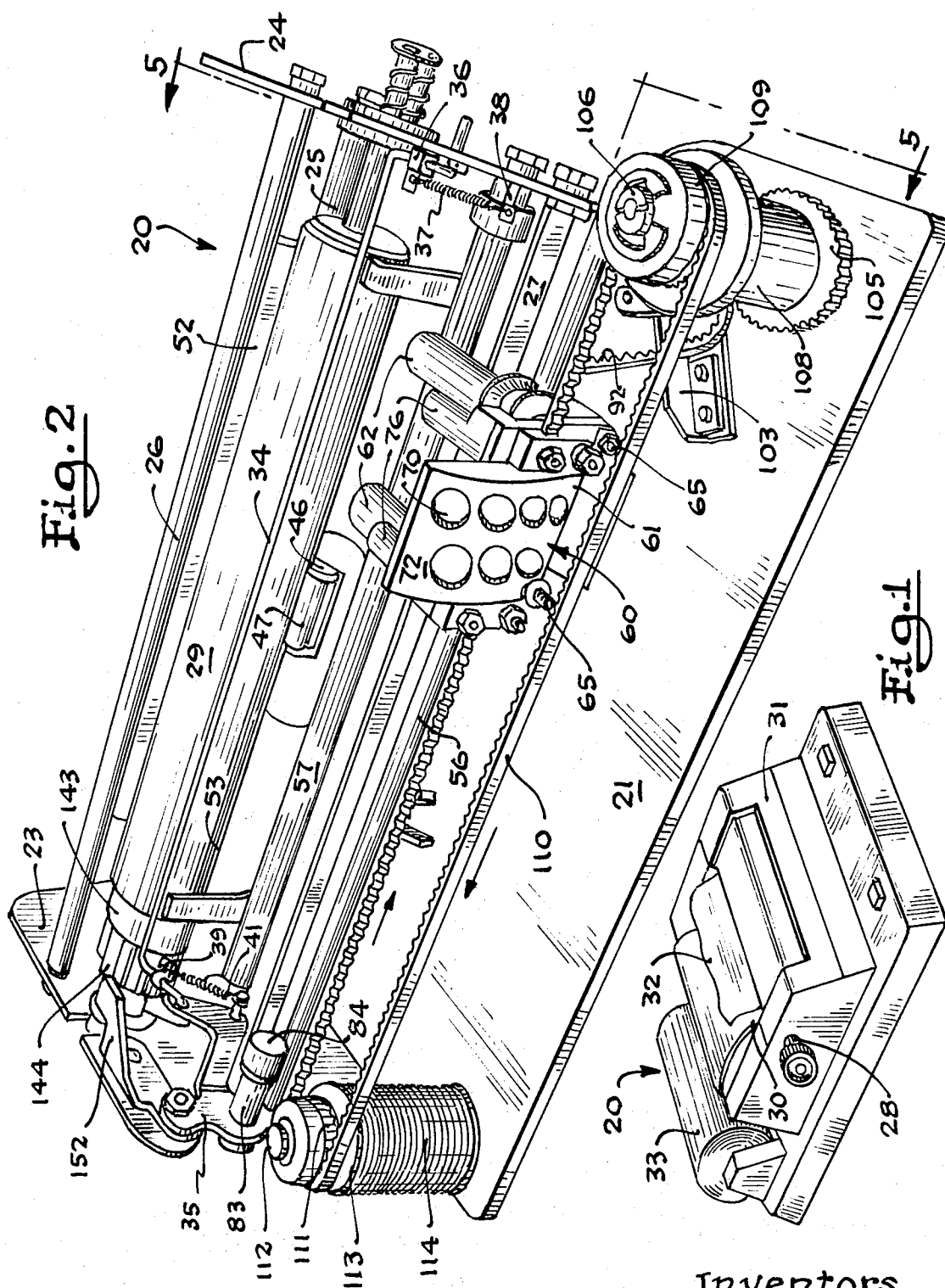
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[57] **ABSTRACT**

A carriage drive for a high speed dot matrix printer, including a reversible stepping motor connected through a clutch to a rotary driven member that is in turn connected by a belt to the printer carriage. The clutch remains engaged as long as the motor operates in a character-spacing direction, but reversal of the motor disengages the clutch and permits a torsion spring to drive the carriage back to a line start position. Near the end of the return movement, a flywheel decelerator absorbs the kinetic energy of the carriage and then utilizes that kinetic energy to prevent bouncing of the carriage.

14 Claims, 14 Drawing Figures





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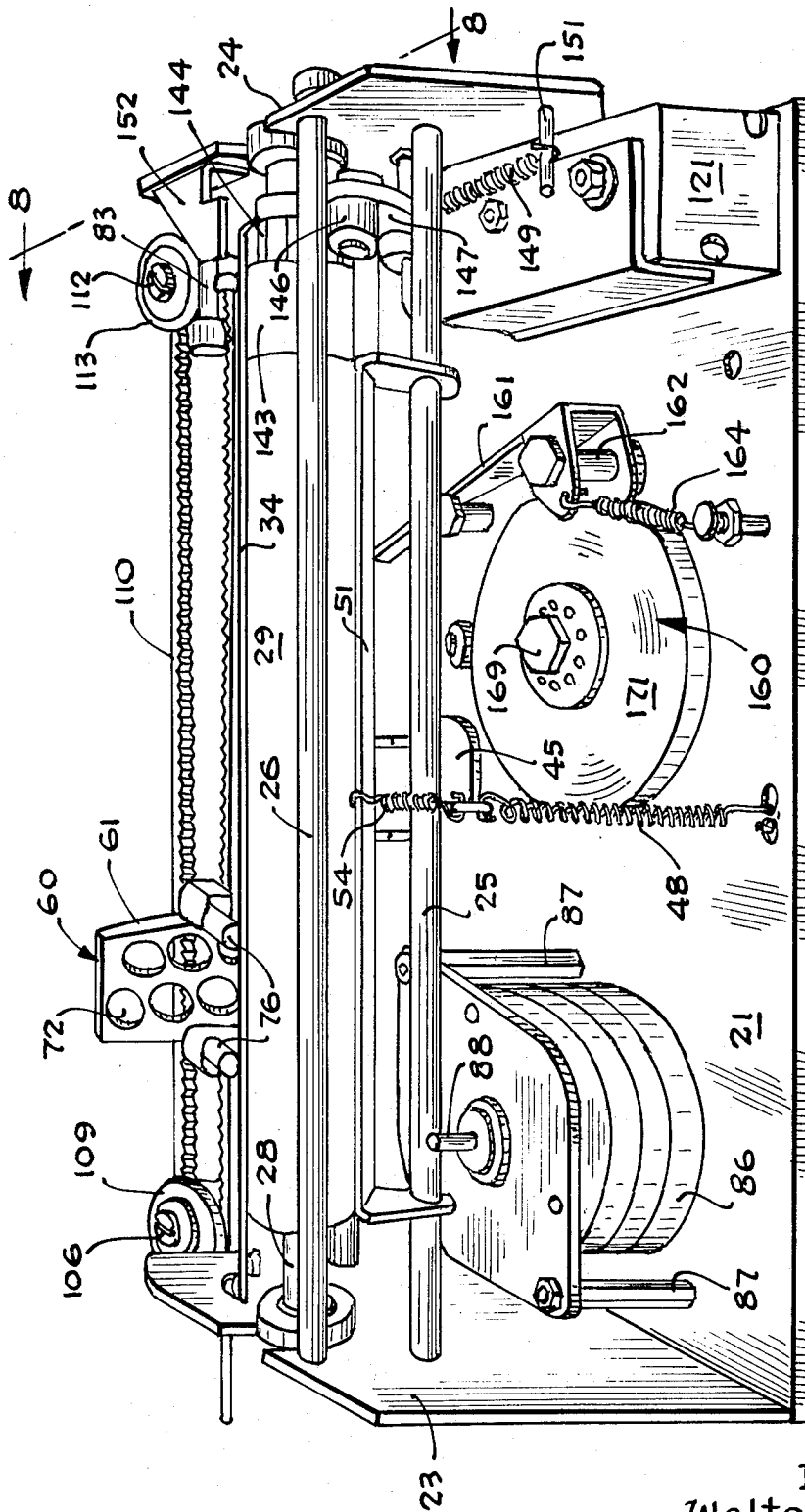
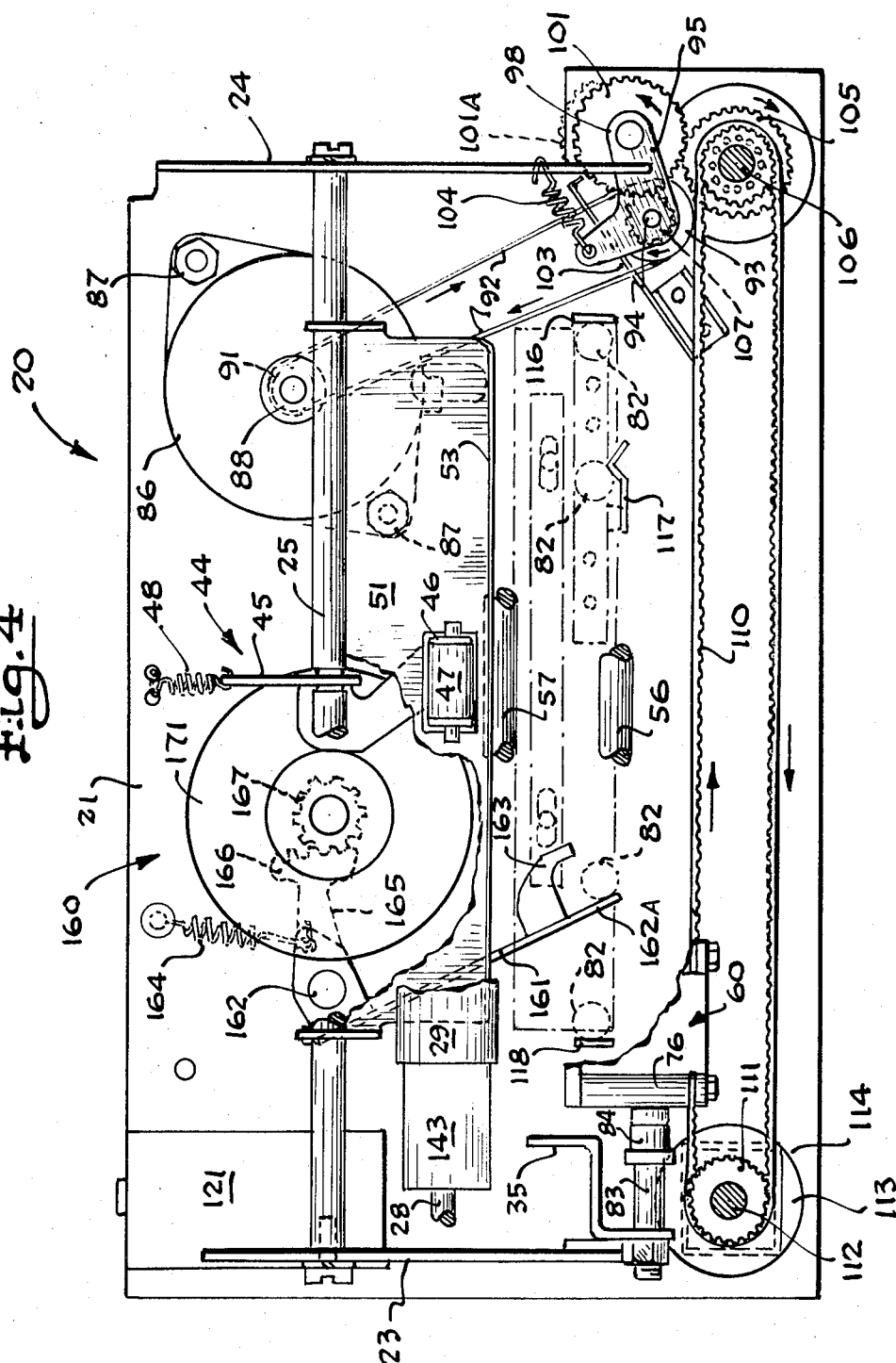


Fig. 3

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Fig. 4



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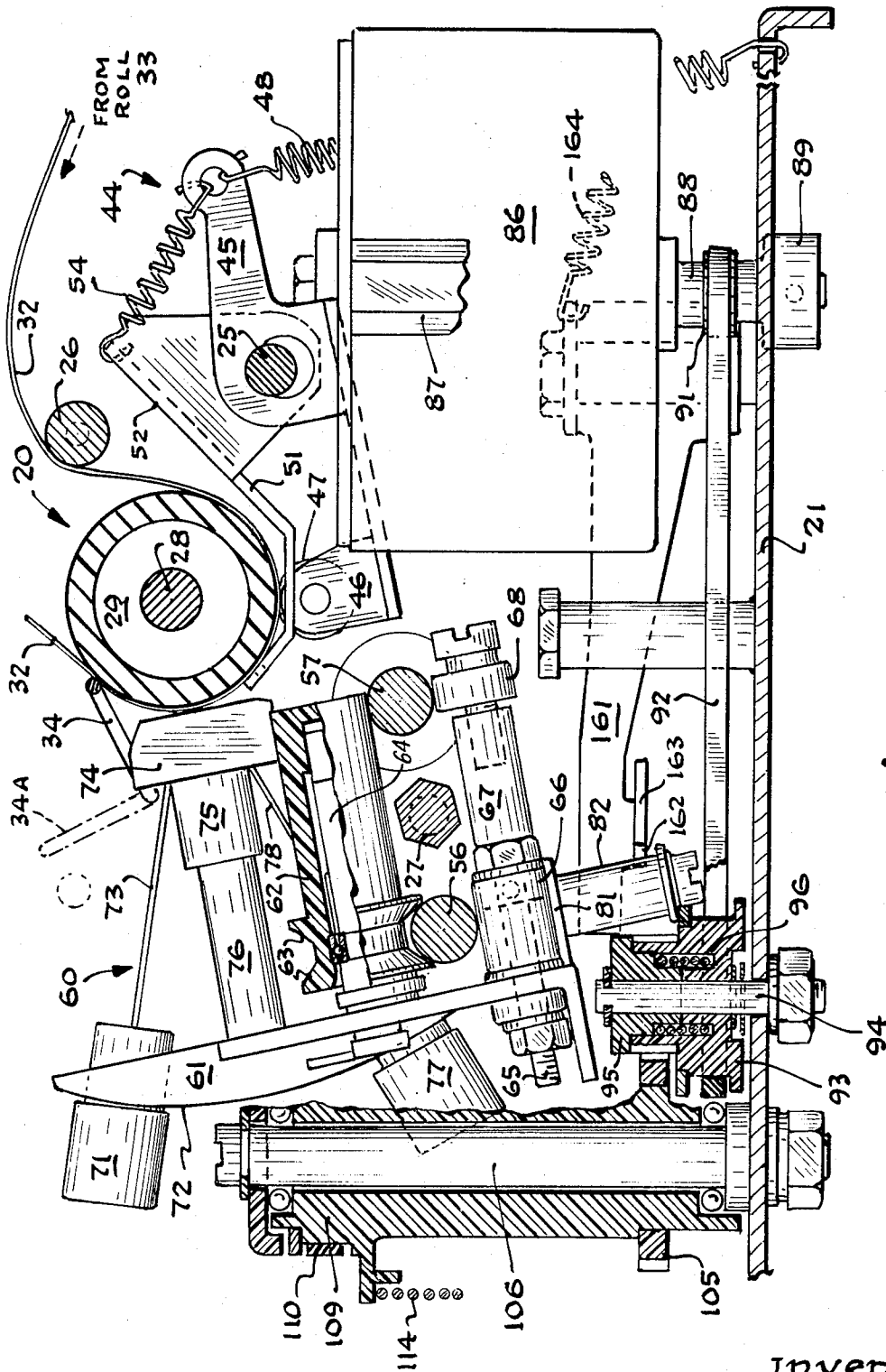


Fig. 5

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Fig. 6

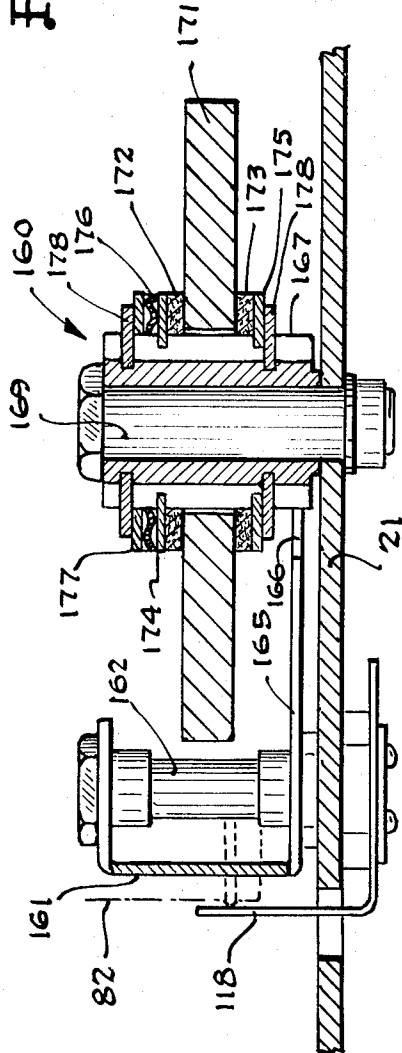
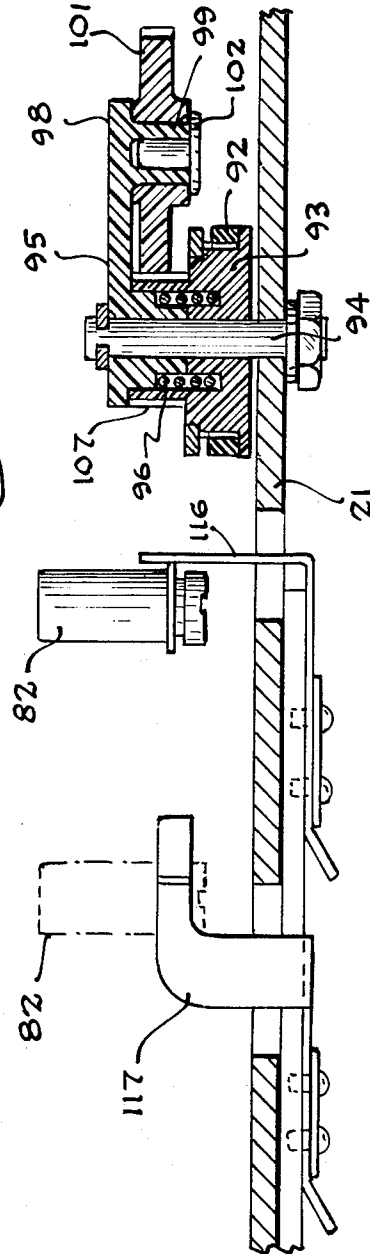


Fig. 7



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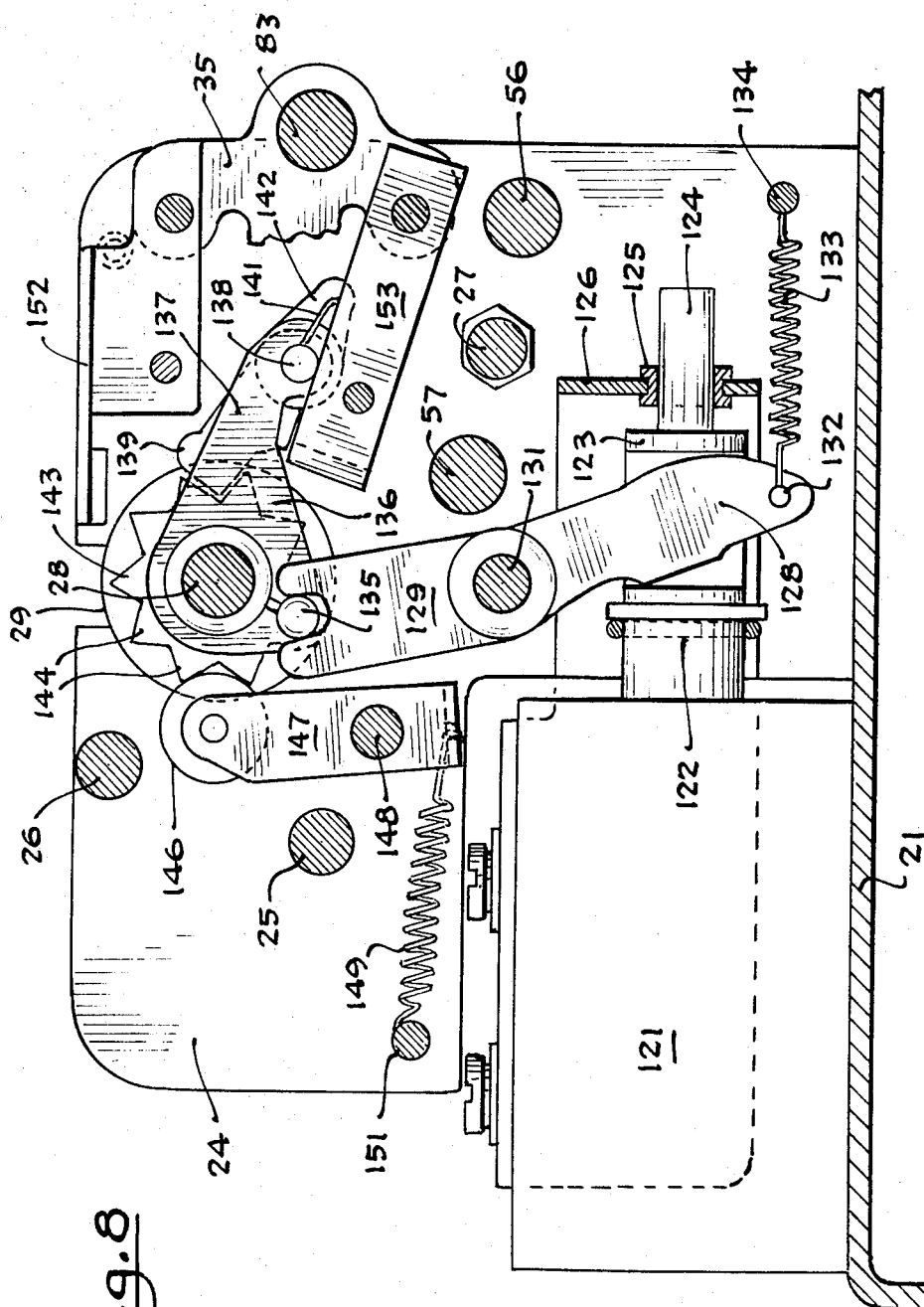


Fig. 8

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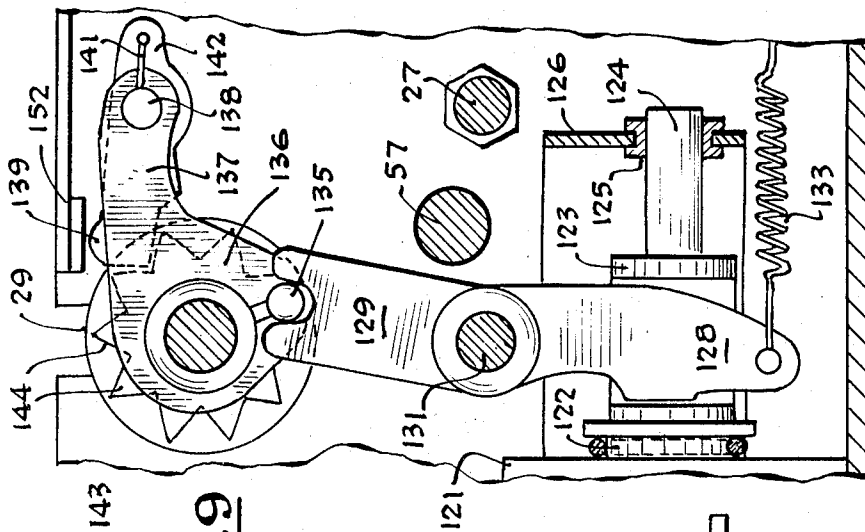


Fig. 9

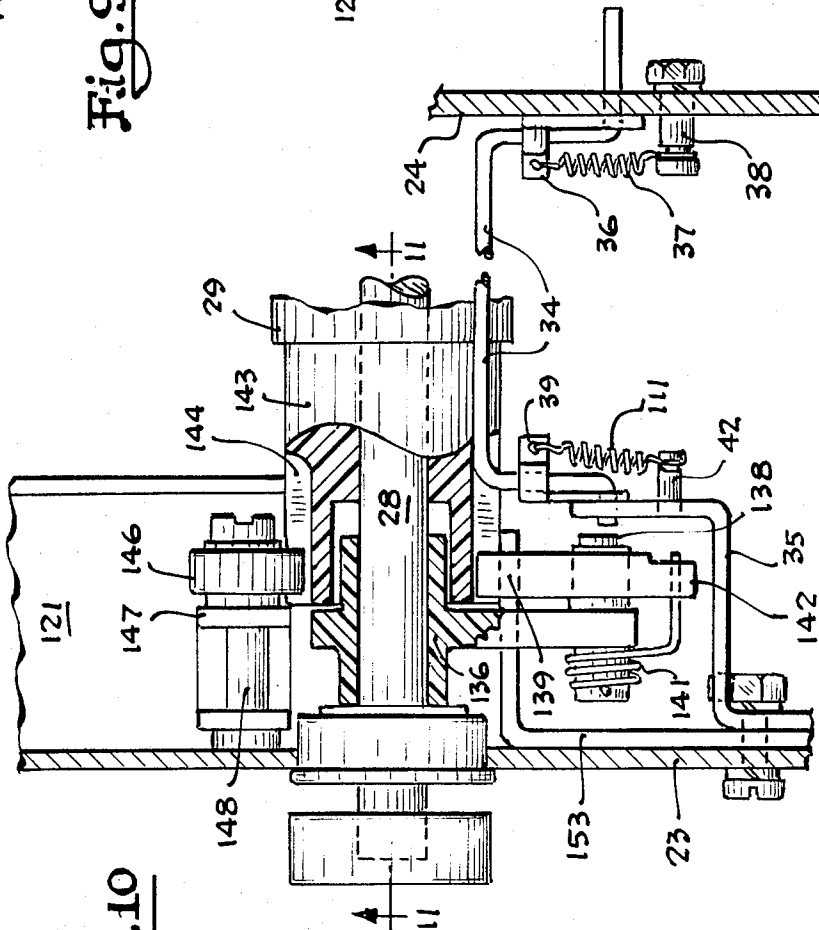


Fig. 10

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Fig. 12

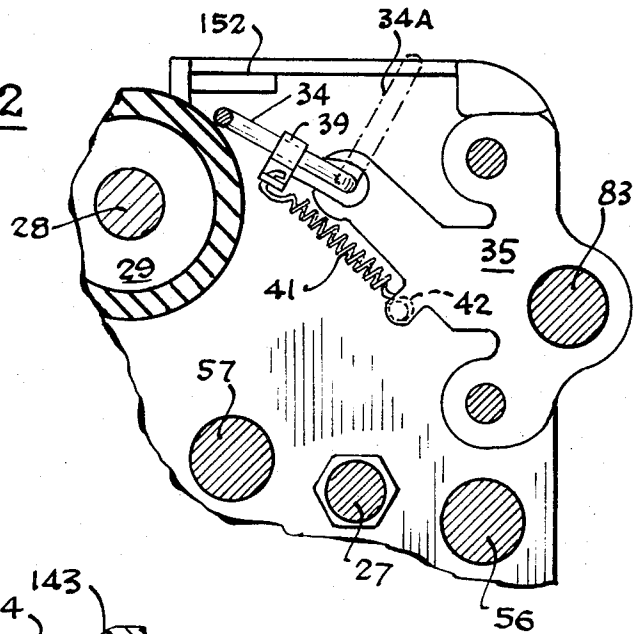
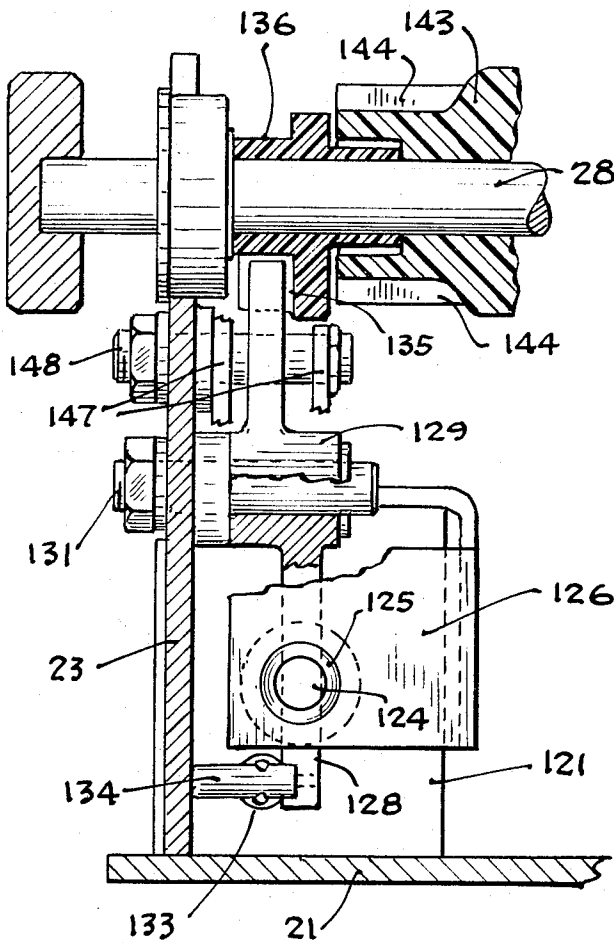


Fig. 11



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Fig. 13

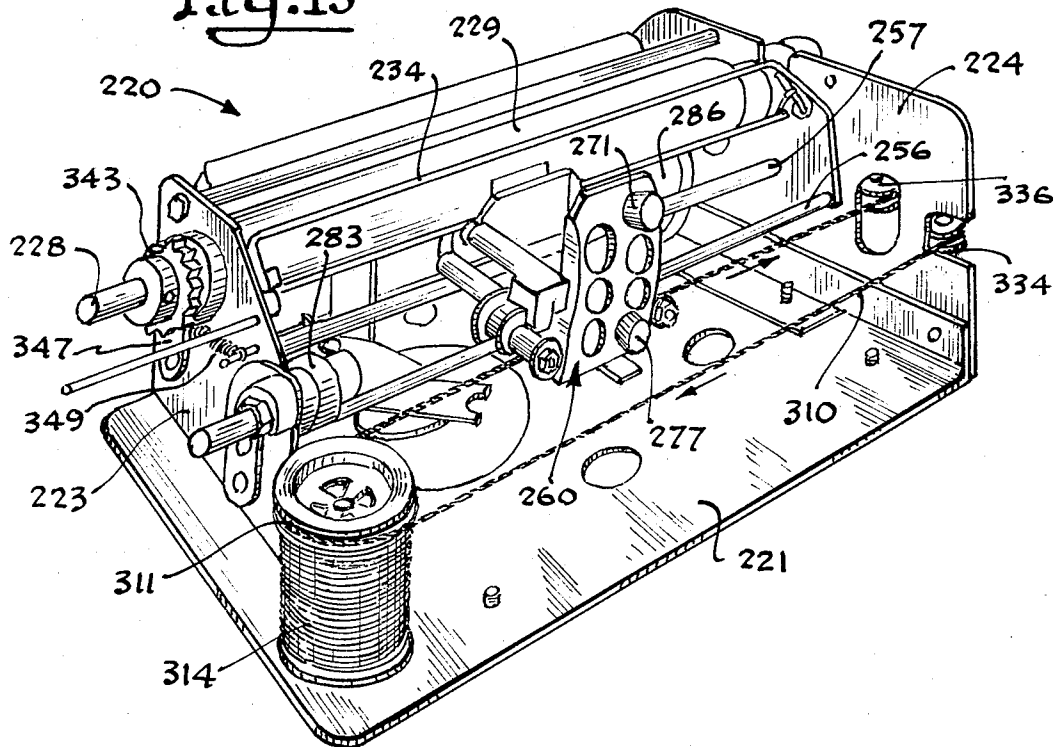
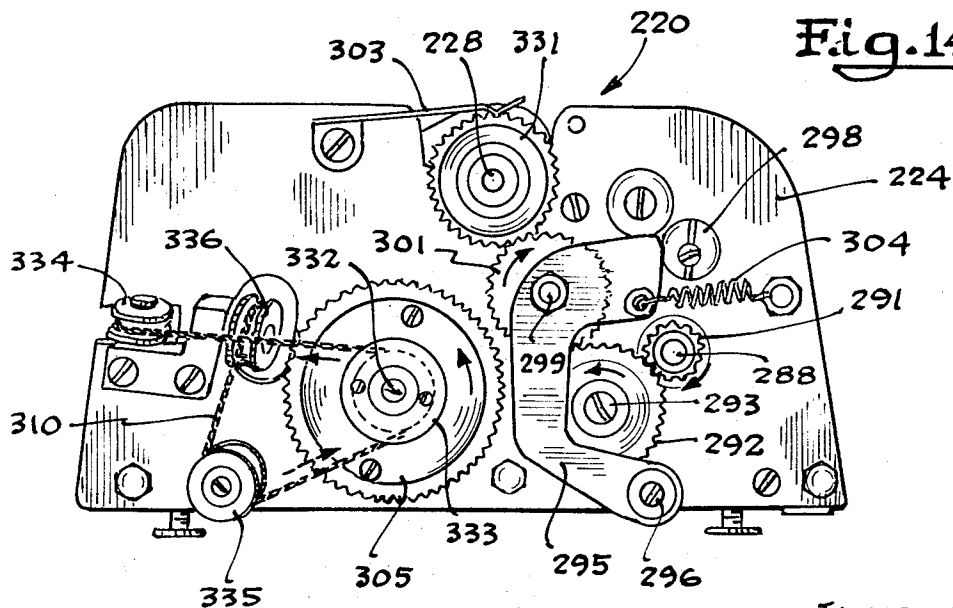


Fig. 14



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CARRIAGE DRIVE FOR HIGH SPEED PRINTER

BACKGROUND OF THE INVENTION

In a wide variety of different kinds of high speed printers, a carriage is moved in incremental steps along a given path in the course of the printing operation. In some typewriters, in conventional telegraphic printers, and in many other printing machines the increments of advance are usually equal to one character width. In other machines, and particularly in some forms of dot matrix printers, the incremental carriage movements are much smaller. For example, in a dot matrix printer the carriage may advance eight distinct steps in the formation of each character, five steps for the formation of five individual columns of dots that form a character and three additional steps to afford a blank space between that character and the next character in the line.

In any of these printing machines, the overall speed and efficiency of the printer is dependent to a considerable extent on a rapid return of the carriage from the end of one line to the starting point for beginning the next line. During the carriage return operation, it is usually necessary to advance a sheet of paper or a paper web by one line space in the printing machine. Except for the time required for a line space operation, however, the entire carriage return interval is completely wasted.

In some high speed printers, spring return mechanisms have been used to return the carriage rapidly from the end of one line to the beginning of the next line. These spring devices can be constructed to afford a high speed carriage return movement, materially reducing the wasted time. But a spring return for the carriage frequently creates other problems. In particular, when the carriage reaches the end of its return movement, travelling at a high speed, it tends to bounce; if bouncing occurs, it is necessary to wait an additional period of time until it is suppressed or to accept printing irregularities at the beginning of each line. Another difficulty results from the need to release the carriage from its normal driving connection to the motor or other drive apparatus that advances the carriage incrementally from the beginning of the line, in order to allow operation of the return spring. In general, it is rather difficult to adapt conventional clutches or like mechanisms to afford adequately rapid release of the carriage while retaining the capability of restoring the normal incremental drive connection to the carriage as soon as it reaches the beginning line position.

SUMMARY OF THE INVENTION

It is a principal object of the present invention, therefore, to provide a new and improved carriage drive for a high speed printer, and particularly a carriage drive of the kind that utilizes a spring mechanism to achieve rapid return movement of the printer carriage from any intermediate position on a line back to an initial position to start a new line.

A particular object of the invention is to provide a new and improved carriage drive for a high speed printer, especially adapted for use in a dot matrix printer, that affords accurate, consistent, and rapid movement of the carriage in extremely short increments, with several increments to each character width.

Another specific object of the invention is to provide a new and improved decelerator for the carriage of a high speed printer that effectively minimizes any bounce of the carriage as the carriage reaches its initial position, upon return from an advanced position.

Accordingly, the invention is directed to a carriage drive for a high speed printer of the kind comprising a carriage movable in predetermined incremental steps along a given path in a character-spacing direction from an initial position toward a limit position and movable back along that path to its initial position from any position on the path. The carriage drive comprises a rotatable drive member and reversible drive means, preferably a reversible electrical stepping motor, for rotating the drive member in incremental steps in either a nor-

mal direction or a reverse direction. A rotatable driven member is operatively connected to the carriage of the printer and is employed to drive the carriage in its character-spacing direction when the driven member is rotated in a first direction. The carriage drive includes clutch means for coupling the drive member to the driven member to rotate the driven member in the aforementioned first direction in response to rotation of the drive member in its normal direction; the clutch means, however, is actuatable to a disengaged position whenever the drive member is rotated in its reverse direction. Spring return means are provided for moving the carriage in its return direction, independently of the drive means, whenever the clutch is disengaged. A carriage decelerator is provided for engaging and braking the carriage, as the carriage approaches its initial position. The decelerator also uses the kinetic energy of the returning carriage to hold the carriage in its initial position, without bouncing, once that position is reached.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a high speed printer in which the carriage drive of the invention may be employed;

FIG. 2 is a front perspective view of a high speed printer incorporating the carriage drive of the present invention, with the cover and some other parts of the printer stripped away;

FIG. 3 is a rear perspective view of the printer of FIG. 2;

FIG. 4 is a cut away plan view of the printer, with most of the platen and carriage omitted;

FIG. 5 is a sectional side elevation view taken approximately as indicated by line 5—5 in FIG. 2;

FIG. 6 is a detail sectional view of a decelerator incorporated in the carriage drive;

FIG. 7 is a detail sectional view of a clutch and certain sensing switches included in the carriage drive;

FIG. 8 is a sectional side elevation, partially cut away, taken approximately along line 8—8 in FIG. 3;

FIG. 9 is a detail, from FIG. 8, showing an alternate operating condition;

FIG. 10 is a detail plan view, partly in cross section;

FIG. 11 is a detail sectional view taken approximately along line 11—11 in FIG. 10;

FIG. 12 is a detail view of a part of the apparatus that has been cut away in FIG. 8;

FIG. 13 is a front perspective view of a high speed printer incorporating another embodiment of the carriage drive of the present invention; and

FIG. 14 is a side elevation view of the printer of FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 through 12 illustrate a high speed printer 20, comprising a dot matrix printer, that incorporates a carriage drive constructed in accordance with a preferred embodiment of the present invention. Printer 20 comprises a base 21; two vertical side plates 23 and 24 are mounted upon base 21 at the left- and right-hand sides, respectively, of the printer. The spacing between the upper parts of side plates 23 and 24 is effectively maintained by a series of tie rods that span the distance between the side plates. These include a rear tie rod 25, an upper tie rod 26, and a lower tie rod 27, joining plates 23 and 24 and base 21 in a rigid frame.

A platen shaft 28 extends across the upper central portion of printer 20; shaft 28 is journaled in bearings mounted in the two side plates 23 and 24. Shaft 28 carries a hollow platen 29, described more fully hereinafter. Platen 29 is accessible through an opening 30 that extends across the top of the metal cover 31 for printer 20 (FIG. 1). A sheet of paper 32, which may be a part of a continuous web drawn from a roll 33, extends into the housing 31, around the platen 29, and back out as shown in FIGS. 1 and 5. A separate sheet of paper can be used if desired.

Since printer 20 is a dot matrix printer, it is essential that the paper 32 be held tightly against platen 29 at the point of print-

ing impact within the machine, in order to avoid perforation of the paper. This is accomplished in part by a wire bail 34 that extends across the entire width of platen 29. The opposite ends of bail 34 are pivotally mounted to the frame of the printer. The right hand end of bail 34, as seen in FIGS. 2 and 10, is pivotally mounted in side plate 24, whereas the opposite end of the bail is pivotally mounted in a bracket 35 that is affixed to side plate 23. At the end of the bail adjacent plate 24, a lug 36 is mounted on the bail; lug 36 is connected to a spring 37, the other end of the spring being connected to a post 38 mounted upon side plate 24. At the other end of bail 34, a lug 39 is mounted on the bail and is connected to a spring 41 having its opposite end connected to a projecting post 42 on bracket 35. Springs 37 and 41 normally maintain bail 34 in firm contact with platen 29, as shown particularly in FIGS. 2, 10 and 12. However, the bail can be pivoted away from the platen to a second stable position, shown by dash outline 34A in FIGS. 5 and 12, to facilitate renewal of the paper supply for the printer.

Printer 20 also includes a pressure roll assembly 44 that is best illustrated in FIGS. 4 and 5. The pressure roll assembly comprises a pressure roll support lever 45 that is pivotally mounted at a central point upon the rear tie rod 25. One end of lever 45 projects down beneath platen 29. It terminates in a U-shaped bracket 46 in which a pressure roll 47 is mounted. At the opposite end of lever 45, a spring 48 is connected to the lever, the other end of spring 48 being connected to base 21. It is thus seen that spring 48 continuously maintains roller 47 in firm contact with paper 32, pressing the paper against platen 29 (FIG. 5).

A paper guide 51 is also mounted upon tie rod 25 (FIGS. 4 and 5). Guide 51 affords a sloped guide surface 52 that guides the paper web 32 into contact with platen 29 (FIG. 5). The paper guide 51 terminates at a lip 53 (FIGS. 4 and 5) that extends across the entire width of the platen. A spring 54 connects guide 51 to the pressure roll support lever 45 so that both members can be displaced from platen 29 simultaneously if this is necessary or desirable to facilitate clearance of a paper jam or for maintenance activities.

At the front of the high speed printer 20, as shown in FIGS. 2, 4 and 5, two carriage guide rails 56 and 57 extend across the printer from side plate 23 to side plate 24; the two guide rails are located on opposite sides of the lower tie rod 27. A print carriage 60 is mounted upon guide rails 56 and 57 and moves longitudinally of the guide rails, from left to right as seen in FIG. 2, in printing each line.

As shown in FIG. 5, carriage 60 includes a vertically extending print magnet support member 61 from which two cantilever upper carriage support rollers 62 project. Each of the carriage support rollers 62 includes a pair of spaced flanges 63 that engage the upper surface of carriage guide rail 56 to maintain carriage 60 in accurate alignment on the guide rails, preventing shifting of the carriage in a direction along the axes of carriage support rollers 62. The free end of each of the support rollers 62 is of circular cross sectional configuration and merely rests upon the other carriage guide rail 57. Each of the two upper support rollers 62 is preferably formed of molded plastic and is rotatably supported upon a metal cantilever shaft 64 that is mounted upon support member 61.

At the lower end of support member 61, two shafts 65 are mounted upon the carriage, projecting from support member 61 beneath guide rail 56. On each of the shafts 65 there is a roller 66 that engages the lower surface of guide rail 56 (FIG. 5). In addition, each shaft 65 is provided with an extension 67 that carries a second roller 68 which engages the bottom surface of guide rail 57. The rollers 66 and 68 are each vertically aligned with one of the upper support rollers 62, maintaining carriage 60 in fixed accurate alignment with respect to the guide rails 56 and 57 throughout the movement of the carriage along the path defined by the guide rails.

The particular dot matrix utilizes in printer 20, in the reproduction of alphabetic and numeric characters, is a 5 × 7 matrix, seven dots high and five dots wide. A full column of

seven dots is reproduced in one operation, requiring seven individual dot printing devices in vertical alignment. Two of these dot printing devices are illustrated in FIG. 5. The upper dot printing device shown therein comprises a print magnet 71 mounted upon the curved outer surface 72 of support member 61; magnet 71 projects through an opening 70 in support member 61, the opening 72 being shown in FIG. 2. An elongated, stiff needle-like print wire 73 projects from print magnet 72 through a print wire guide 74, terminating at a point immediately adjacent the surface of platen 29. Guide 74 is mounted upon a bracket 75 that is supported upon a pair of cantilever print guides 76 mounted upon carriage support member 61. The lower-most printing device, also illustrated in FIG. 5, comprises a similar print magnet 77 mounted upon the arcuate outer surface 72 of support member 61. Print magnet 77 actuates an elongated needle-like print wire 78 which, like needle 73, projects from the print magnet through the needle guide 74 and terminates at a point immediately adjacent the surface of platen 29. The remaining five printing devices have been omitted from the drawing; the apertures for mounting the remaining printing devices on support member 61 are shown in FIG. 2.

There is a projection 81 extending inwardly from the lower end of support member 61 (FIG. 5). An actuator member 82 is mounted upon projection 81 and extends downwardly from carriage 60. Actuator 82 is utilized to actuate a series of control switches, as described hereinafter, and is also employed as a connecting member in the carriage decelerator that is a part of the present invention, as described hereinafter.

At the left-hand side of printer 20, as seen in FIGS. 2 and 4, an adjustable stop 83 is mounted upon side plate 23. Stop 83 is a cantilever device that projects from side member 23 toward the carriage, terminating in a replaceable cushion member 84 formed of rubber or other like resilient material.

The carriage drive of the present invention, in printing machine 20, comprises a reversible electric stepping motor 86 mounted upon a pair of vertical posts 87 as shown particularly in FIGS. 3, 4 and 5. The shaft 88 of motor 86 extends in a vertical direction, and the lower end of the shaft is journaled in a bearing 89 mounted upon base 21 (FIG. 5). The lower end of shaft 88 carries a pulley 91 that engages a toothed drive belt 92 of the kind commonly referred to as a timing belt. Belt 92, at its other end, engages a rotatable drive pulley 93 that is mounted upon a short vertical shaft 94 as shown in FIGS. 4, 5 and 7. An idler support lever 95 is also pivotally mounted upon shaft 94. Lever 95 and pulley 93 are formed with complementary spaced parallel walls and a helical spring 96 is mounted in the space between members 93 and 95, as best shown in the sectional views of FIGS. 5 and 7. One arm 98 of the idler support lever 95 includes a downwardly extending shaft portion 99 upon which an idler gear 101 is mounted by means of a retainer 102 (FIG. 7). The idler support lever 95 is also connected to a spring 104 that is anchored to side plate 24. A detent spring 103, mounted on base 21, projects into alignment with idler gear 101, but does not normally engage the idler.

Spring 104 normally biases the idler support member 95 in a clockwise direction, maintaining idler 101 in meshing engagement with a driven gear 105 mounted upon a vertically extending shaft 106. Idler 101 is always in mesh with a pinion gear 107 that is formed as an integral part of the rotatable drive pulley 93. Thus, idler 101 normally affords a positive driving connection between the rotatable drive member 93 and the rotatable driven member 105; however, this drive connection can be interrupted quite easily and quickly by rotation of the idler support lever 95 as described more fully hereinafter.

The driven gear 105 is affixed to an elongated sleeve 108 that is mounted upon shaft 106 by appropriate bearings, preferably ball bearings as illustrated in FIG. 5. The upper end of sleeve 108 includes a pulley section 109 that engages a carriage driven belt 110. The carriage drive belt 110 is preferably a toothed flexible drive belt of the kind generally referred to as

a timing belt. One end of the carriage drive belt 110 is fastened to the right-hand side of the print carriage 60. The other end of the carriage drive belt extends around a pulley 111 and is secured to the left-hand side of carriage 60, as shown particularly in FIGS. 2 and 4.

Pulley 111 is mounted upon a vertical shaft 112 and is part of an elongated sleeve 113 substantially similar in construction to the sleeve 108. A torsion spring 114 is affixed to one end of sleeve 113, and the other end of torsion spring 114 is secured to base 21. The orientation of torsion spring 114 is such that, as carriage 60 moves from left to right in the printing of a line, the torsion spring is wound tighter and tighter. Torsion spring 114 comprises a spring return means for moving carriage 60 back to its initial position, in engagement with stop 83, to begin each new line of printing.

As carriage 60 moves from left to right across printer 20, along the path defined by guide rails 56 and 57, actuator 82 serves to indicate arrival of the carriage at certain critical positions. At the right-hand end of printer 20, a sensing switch element 116 projects upwardly through base 21 in position to engage actuator 82 (see FIGS. 4 and 7). Sensing switch element 116 defines the right-hand limit of travel for carriage 60. To the left of sensing switch element 116, there is another sensing switch element 117 that also projects upwardly through base 21 in position to engage actuator 82 on carriage 60. Sensing switch element 117 is located at an arbitrarily defined position from which the carriage should be returned to the initial position at stop 83 once the printing of a word is completed. In one form of printer 20, using a 48 character line, sensing switch element 117 has been located to identify the completion of the printing of a total of 40 characters. Another sensing switch element 118 projects upwardly through base 21 at the left-hand end of the path of movement of carriage 60. Sensing switch element 118, shown in FIGS. 4 and 6, is engaged by actuator 82 to signal the completion of a carriage return movement, being engaged by actuator 82 when the carriage has been returned to its initial position in engagement with stop 83.

The line space mechanism for printer 20 is best illustrated in FIGS. 8-11, although parts of this mechanism also appear in other views. The line space mechanism comprises a solenoid 121 having an armature 122 upon which a U-shaped plunger 123 is mounted. A shaft 124 extends beyond plunger 123 and is engaged in a guide 125 in a fixed guide bracket 126. The U-shaped bracket 123 engages the lower end 128 of an operating lever 129 that is pivotally mounted on a short shaft 131 supported upon side plate 23. The lower end 128 of operating lever 129 carries a pin 132 to which a spring 133 is connected; the other end of spring 133 is connected to a post 134 mounted upon side plate 23 (FIGS. 8 and 9).

The upper end of operating lever 129 is bifurcated and engages a pin 135 on a rocker arm 136. Rocker arm 136 includes an extension 137 that carries a pin 138. A pawl 139 is pivotally mounted upon pin 138. A helical biasing spring 141 is mounted upon an extension of pin 138; one end of the spring is affixed to the pin and the other end is engaged in an extension 142 of pawl 139. A fixed upper stop 152 and a fixed lower stop 153 are mounted on side plate 23, extending outwardly from the side plate above and below the pawl.

Rocker arm 136 is rotatably mounted upon the end of platen shaft 28 adjacent side plate 23. It is positioned immediately adjacent a detent wheel 143 that is affixed to the platen shaft 28. A press fit, supplemented with adhesive, may be employed. The detent wheel 143 is provided with a series of teeth 144 positioned in alignment with and engaged by pawl 139. The teeth 144 on detent wheel 143 are also engaged by a detent roller 146 mounted upon a lever 147 that is pivotally mounted upon a shaft 148 affixed to side plate 23. Detent roller 146 is maintained in engagement with detent wheel 143 by a spring 149 having one end connected to the bottom of lever 147 and the opposite end connected to a post 151 mounted upon side plate 24 (FIGS. 3 and 8).

The carriage drive of the present invention includes a decelerator system 160, best illustrated in FIGS. 3-6. Decelerator 160 comprises a low-inertia carriage-engaging means including an operating lever 161 that is pivotally mounted on a post 162 affixed to base 21. The end of lever 161 that projects toward the front of the printing machine 20 is bifurcated to afford a sensing element 162A and a restraining element 163; the sensing element 162A is normally disposed in the path of the actuator 82 of the printing machine carriage as shown in FIG. 4. Operating lever 161 is normally maintained in the position illustrated in FIG. 4 by a biasing spring 164.

The operating lever 161 of decelerator 160 includes an arm 165 that terminates in a gear segment 166. Gear segment 166 is disposed in meshing engagement with a driven gear 167, FIG. 4, that is a part of a high-inertia acceleration-resisting means for controlling carriage deceleration. As shown in FIG. 6, gear 167 is mounted upon a post 169 that is affixed to and projects vertically upwardly from base 21. A relatively large and heavy flywheel 171 is rotatably mounted upon the central portion of gear 167. A pair of felt washers 172 and 173 are disposed upon the top and bottom surfaces, respectively, of flywheel 171 and are keyed to gear 167. The felt washers 172 and 173 are engaged by two mounting washers 174 and 175, respectively. The entire assembly is maintained in good frictional contact by a spring washer 176, interposed between washer 174 and an additional washer 177; a pair of retainer rings 178 complete the high-inertia acceleration-resisting assembly.

In considering the operation of printing machine 20, and particularly the carriage drive of the printing machine which constitutes the subject matter of the present invention, the best starting point is at the beginning of a line, with the carriage 60 displaced to the extreme left-hand end of its path in contact with the rubber bumper 84 on the adjustable stop 83 (FIG. 4). With the carriage in this position, actuator 82 is in engagement with the left-hand limit switch 118. This is the initial position for the imprinting of each line of characters by the printer.

To start printing, motor 86 is energized to rotate shaft 88 in a clockwise direction, as viewed in FIG. 4, driving belt 92 in the direction indicated by the arrows. This is the normal direction of rotation for motor 86 and the normal direction of movement for belt 92 for printing operations. Motor 86 is a stepper motor and moves in predetermined incremental steps, so that the movement of its shaft 88, belt 92, and the remainder of the carriage drive always occurs in closely controlled incremental steps as the carriage performs its character spacing movements along guides 56 and 57.

The normal movement of belt 92, as indicated by the arrows, causes the rotatable drive member comprising pulley 93 and gear 107 to rotate in a clockwise direction. Accordingly, idler 101 is driven in a counterclockwise direction, and the idler drives gear 105 in a clockwise direction. Thus, belt 110 is driven in a character spacing direction, as indicated by the arrows in FIGS. 2 and 4, in response to the clockwise rotation of the driven member 105 in the drive system that connects motor 86 to carriage drive belt 110.

As long as appropriate energizing signals are received by motor 86, and until it is necessary to return the carriage to its initial position to begin a new line, the drive system steps carriage 60 along platen 29, from left to right, as described above. In a typical 5 × 7 dot matrix printer, five character-space steps are used for the actual imprinting of each alphabetic, numeric, or other character. Usually, energizing signals are supplied to motor 86 in groups of eight, with the additional three increments being utilized for spacing between adjacent characters. When a space between words is required, motor 86 is stepped for the same number of increments, or any desired number of increments, without the application of energizing signals to any of the printing devices on carriage 60.

Printer 20 may be required to reproduce continuous copy that does not include appropriately timed carriage return

signals. This mode of operation is facilitated by the provision of sensing switch 117, which is located a selected number of character spaces from the absolute end of line sensing switch 116 (FIG. 4). When switch 117 is contacted by the actuator 82 on carriage 60, the sensing switch operates a control circuit (not shown) for printer 20 that initiates a carriage return operation upon the next occurrence of a space signal in the telegraphic signal input to the printer. As noted above, switch 117 may be located about eight characters to the left of the sensing switch 116. Switch 116, on the other hand, is utilized to initiate a carriage return operation instantly upon contact by actuator 82 to prevent loss of copy that could result if carriage 60 were retained at the far right.

In the formation of each character, the individual print wires (e.g., print wires 73, 78, FIG. 5) print a number of dots upon the paper 32 that extends around platen 29. The printing operation goes forward at a high rate of speed; in a typical commercial printer, the printing rate is approximately 600 characters per minute.

When a carriage return is triggered, whether by a received telegraphic signal or by the operation of either of the switches 116 and 117, the direction of rotation of motor 86 is reversed. As a consequence, drive belt 92 is driven in a direction opposite to the arrows (FIG. 4) and pulley 93 starts to rotate in a counterclockwise direction. Counterclockwise rotation of pulley 93 causes spring 96 to tighten and grip the walls of both of the members 93 and 95 (FIGS. 5 and 6). As a consequence, the idler support lever 95 begins to pivot in a counterclockwise direction to move idler 101 out of engagement with the driven gear 105 (FIG. 4). In a predetermined number of incremental steps of motor 86, in its reverse direction, idler 101 is moved to its alternate position 101A, completely free of gear 105 and in engagement with detent spring 103. It is thus seen that the idler support member 95, idler gear 101, and spring 96 constitute a clutch means that couples drive member 107 to driven member 105 to rotate the driven member 105 in a first clockwise direction in response to rotation of the drive member 93, 107 in its normal direction; however, this same clutch means is automatically and promptly actuated to a disengaged condition in response to reverse rotation of the drive member 107. In one commercial machine, disengagement of the clutch is effected in four cycles of operation of stepper motor 86.

As soon as the clutch mechanism comprising idler 101 is disengaged, carriage 60 is free to move in response to the biasing force supplied by the torsion spring 114. Spring 114 has been tightened with each increment of movement of carriage 60 during the printing of a line; if the carriage has been moved to near the right-hand end of its path, as shown in FIG. 2, torsion spring 114 is tightly wound and exerts a considerable force upon belt 110. As a consequence of disengagement of the clutch idler gear 101, carriage 60 is rapidly accelerated in a return direction, back toward its initial position in engagement with stop 83.

As carriage 60 moves in its reverse direction toward stop 83, the actuator 82 on the carriage contacts the sensing extension 162A of the operating lever 161 for decelerator 160. The continuing movement of the carriage rotates operating lever 161 in a clockwise direction and imparts a similar rotation to the gear segment 166. This rotates gear 167 in a counterclockwise direction, as viewed in FIG. 4.

If the carriage return operation has been initiated with the carriage only a short distance along the line, as occurs when only a short line is printed, torsion spring 114 is wound up to only a limited extent and exerts a relatively small force on belt 110. Under these circumstances, carriage 60 moves relatively slowly in the return direction and actuator 82 is moving quite slowly when it engages the sensing extension 162A of operating lever 161. The slow movement of lever 161 and its gear segment 166 results in a relatively slow movement of gear 167. The slow movement of gear 167 offers little resistance to the movement of actuator 82 because the acceleration is minimal. Carriage 60 contacts the resilient pad 84 on stop 83 at a slow speed, with little tendency toward bouncing.

On the other hand, when a long line of characters has been imprinted and carriage 60 starts its return movement from at or near the right-hand end of its travel, the torsion spring 114 has been wound much more tightly and applies a much greater force to the carriage. Moreover, under these circumstances there is a greater distance for carriage 60 to gain speed. Consequently, actuator 82 strikes sensing extension 162A on operating lever 161 at a high speed, so that gear 167 is accelerated rapidly. When this occurs, the force required to impart a corresponding acceleration to flywheel 171 is greater than the frictional coupling between gear 167 and flywheel 171. Slipping occurs at the faces of felt washers 172 and 173; this frictional brake absorbs nearly all of the kinetic energy of the carriage. When the carriage has been slowed down to a speed matching that of the high-inertia flywheel 171, slipping stops and the braking action terminates. Carriage 60 moves freely but slowly back to its initial position.

The continued return movement of carriage 60 brings it into engagement with the resilient pad 84 on stop member 83. Because the carriage is still moving at a low speed when it reaches stop 83, the carriage may bounce unless restrained. However, the restraining extension 163 on operating lever 161 has now been pulled in behind actuator 82, due to the clockwise movement of lever 161 caused by the return movement of the carriage (FIG. 4). When carriage 60 starts to bounce, therefore, it immediately encounters lever extension 163 and starts to pivot lever 161 in counterclockwise direction. This bouncing movement is prevented by the continuing rotational movement of flywheel 171, which continuously urges lever 163 toward further clockwise rotation. As a consequence, the remaining kinetic energy of carriage 60 is absorbed as a friction loss at the surfaces bounded by the felt washers 172 and 173 (FIG. 6) and the carriage is arrested at its initial position without appreciable bouncing.

When the clutch mechanism comprising idler 101 has been disengaged, and rotation of the idler has been arrested by detent 103, as described above, the clutch remains disengaged until motor 86 is again reversed and resumes rotation in its normal direction. This is accomplished by an electrical signal initiated when actuator 82 contacts the left-hand limit switch 118, indicating that the carriage has again reaches its initial position at the left-hand end of a line. The total minimum time interval required for carriage return and re-engagement of the clutch comprising idler 101 is the time needed for twice the number of incremental steps utilized for disengaging the clutch. Thus, if the clutch is disengaged in response to four steps of reverse movement of motor 86, it is re-engaged by four steps of movement in the normal direction, restoring the printer to condition for further operation in the time required for imprinting a single character. The actual elapsed time may be somewhat longer, depending upon the speed of carriage return and the time required to complete the second reversal of motor 86.

During the carriage return operation, a line space operation is necessary to advance a fresh segment of the paper web 32 into position to receive the next line of printing. In other instances, a separate line space signal may be utilized to initiate a line space operation, as when a blank portion of the paper is to be advanced through the printer to begin a new message.

At the start of a line space operation, the line space mechanism is in the position illustrated in FIG. 8. The line space operation is initiated by energizing solenoid 121, pulling its armature 122 inwardly of the solenoid from the position shown in FIG. 8 to that illustrated in FIG. 9. This movement of armature 122 causes the U-shaped portion 123 of the solenoid plunger to pull the lower portion 128 and the line space lever 129 to the left, pivoting lever 129 in a clockwise direction about its shaft 131. This drives pin 135 to the right, from the position of FIG. 8 to that of FIG. 9 and rotates rocker arm 136 through a limited arc in a counterclockwise direction.

As rocker arm 136 rotates counterclockwise, the engagement of pawl 139 with one of the detent teeth 144 drives detent wheel 143 counterclockwise. The counterclockwise motion of detent wheel 143 is arrested when pawl 139 engages

the upper stop 152. During the rotation of detent wheel 143, the detent roller 146 is driven outwardly against the bias of spring 149 and then moves back inwardly into engagement with the space between the next pair of teeth 144. Thus, the paper advancing movement is completed, with the mechanism in the position shown in FIG. 9.

When the line space operation is complete, solenoid 121 is de-energized. Spring 133 then pulls the lower portion 128 of operating lever 129 back to the right, as seen in FIGS. 8 and 9. This results in a counterclockwise rotation of lever 129 back through a limited arc from the position shown in FIG. 9 to that illustrated in FIG. 8. The rotation of lever 129 drives pin 135 back to its original position and rotates rocker arm 136 clockwise from the position of FIG. 9 to that of FIG. 8. In the course of this movement, pawl 139 rides over one of the detent teeth 144 and, as it clears that tooth, the pawl is snapped back into engagement with the next tooth in response to the bias afforded by spring 141. During this restoration movement, detent roller 146 prevents rotation of detent wheel 143, since the sliding movement of pawl 139 on the detent wheel does not exert enough force to overcome the bias applied to roller 146 by spring 149. Accordingly, the detent wheel 143 and platen 29 remain in the advanced position with a line space movement completed.

The carriage drive incorporated in printer 20 affords a number of advantages in operation of the printer. The clutch mechanism comprising idler gear 101 and its pivotal support 95 disengages rapidly in response to a reversal of rotation of stepper motor 86, initiating the carriage return operation promptly upon the occurrence of conditions requiring a carriage return without requiring a separate motor, solenoid, or other actuator. Disengagement of the clutch does not result in a loss of control or timing for the carriage drive, since the clutch is disengaged in a fixed number of steps of motor 86 and re-engagement of the clutch is effected in a corresponding discrete number of motor steps. Thus, the carriage return operation is completed with the high speed printer fully conditioned for immediate operation in printing the next character.

Torsion spring 114 affords a rapid carriage return operation with a minimum space requirement for the torsion spring. In cooperation with the clutch mechanism of idler gear 101, the torsion spring facilitates a rapid carriage return operation with minimum loss of time.

Decelerator 160 also contributes materially to the advantages of the carriage drive in high speed printer 20. On a rapid carriage return, originating at the far end of the path of carriage travel, the kinetic energy of the carriage is principally dissipated as frictional heat and a small part is converted into rotational energy of flywheel 171; that rotational energy is utilized directly to maintain carriage 60 in contact with stop 83 once the carriage reaches the stop. In this manner, the carriage energy is effectively dissipated or usefully employed to prevent carriage bounce. The decelerator 160, by minimizing bouncing and vibration, inherently reduces the wear and tear on printer 20 from the carriage return operation and quickly stabilizes the carriage at its initial position at the start of each line, maintaining an even left-hand margin in the reproduced copy. Thus, the decelerator contributes materially to a rapid, controlled, well-timed turnaround at the end of the carriage return movement.

Stepper motor 86, as a basic drive element for the carriage drive, contributes to the accurate and consistent advance of carriage 60 along its operating path. The stepper motor, energized with discrete pulses that correspond to the required carriage movements, in combination with timing belt drives and a gear train, so that there are no friction drive components, makes it possible to maintain complete control over the carriage movement at all times.

FIGS. 13 and 14 illustrate a high speed printer 220 that is generally similar in construction, in many respects, to printer 20, and that incorporates a carriage drive constructed in accordance with another embodiment of the present invention. Printer 220 comprises a base 221, with two vertical side plates

223 and 224 mounted on the base. A platen shaft 228 spans the two side plates and supports a platen 229 therebetween. A bail 234 is normally maintained in engagement with platen 229 and holds a sheet of paper (not shown) in printing position on the platen. The printer may include a paper guide, as described in relation to printer 20.

A pair of carriage guide rails 256 and 257 extend across the frame of printer 220, between side plates 223 and 224, parallel to platen 229. A printing carriage 260 is mounted upon rails 256 and 257. Carriage 260 is constructed like carriage 60 of the previous embodiment and is utilized to support a total of seven dot printing devices, as generally indicated by the magnetic wire printer devices 271 and 277. In printing a single line of characters, carriage 260 starts at the left-hand end of guide rails 256 and 257, in contact with a stop member 283, and moves to the right in a series of incremental steps. When a given line is completed, the carriage is returned to its initial position against the stop 283 to begin the next line.

The carriage drive for high speed printer 220 comprises a motor 286 that is mounted upon side plate 224. Motor 286 is an electrical stepper motor. The motor is mounted horizontally, with its shaft 288 projecting outwardly of side plate 224 as shown in FIG. 14.

Motor shaft 288 carries a pinion 291 that is disposed in meshing engagement with a drive gear 292. Drive gear 292 is mounted upon a shaft 293 that is in turn mounted to side plate 224. Drive gear 292 is also in mesh with an idler gear 301. Idler gear 301 is rotatably mounted upon a shaft 299 that is mounted upon an idler support member comprising a lever 295. The idler support lever 295 is pivotally mounted upon a shaft 296 affixed to side plate 224. A bias spring 304 is connected to the idler support member 295 and biases member 295 toward rotation in a clockwise direction, and toward engagement with an adjustable eccentric stop 298. Idler gear 301 is disposed in meshing engagement with a line feed gear 331 that is mounted upon the right-hand end of platen shaft 228. Gear 331 is engaged by a detent spring 303, mounted upon side plate 224, that prevents counterclockwise rotation of gear 331 while permitting clockwise rotation.

Idler gear 301 is also disposed in alignment with a driven member comprising a carriage space gear 305. Gear 305 is mounted upon a shaft 332 supported upon side plate 224; a pulley 333 is affixed to gear 305. Pulley 333 is engaged by a drive string 310. From pulley 333, one end of the drive string 310 extends around a pulley 334 mounted on side plate 224; from pulley 334, drive string 310 extends to a pulley 311 that is mounted concentrically with and is connected to a torsion spring 314. From pulley 311, drive string 310 is extended to and is connected to the left-hand side of the printer carriage 2160 (FIG. 13).

As shown in FIG. 14, the other end of drive string 310 extends from pulley 333 around two additional pulleys 335 and 336 that are mounted upon side plate 224. Drive string 310 continues from pulley 336 to the right-hand end of carriage 260 (FIG. 13).

At the other end of platen shaft 228 from gear 331, a detent wheel 343 is affixed to the shaft (FIG. 13). A detent lever 347 is pivotally mounted upon side plate 223, adjacent detent wheel 343. A detent roller (not shown) is mounted upon lever 347 and is maintained in engagement with detent wheel 343 by an appropriate spring 349, as in the previous embodiment.

When the high speed printer 220 of FIGS. 13 and 14 is placed in operation, character space movement of carriage 260, from left to right along the path defined by the guide rails 256 and 257, is effected by clockwise rotation of the stepper motor shaft 288. Rotation of shaft 288 in a clockwise direction causes pinion 291 to turn drive gear 292 in a counterclockwise direction. The counterclockwise rotation of drive gear 292 in turn rotates idler 301 in a clockwise direction.

The idler 301 attempts to turn the line space gear 331 in a counterclockwise direction. However, counterclockwise rotation of gear 331 is blocked by the spring detent 303. Consequently, idler gear 301 is driven, by reaction against gear

331 and against the bias of spring 304, into engagement with the carriage space gear 305. Gear 305 is rotated in a counterclockwise direction and drives the drive string 310 in the direction indicated by the arrows in both FIGS. 13 and 14. In this manner, the carriage 260 is stepped rapidly and repeatedly along the guide rails 256 and 257, printing a line in the manner described above in connection with printer 20.

As in the previous embodiment, a carriage return operation is initiated in printer 220 by reversing the direction of rotation of the drive motor. Thus, to initiate a carriage return, motor 286 is reversed and its shaft 288 is rotated in a counterclockwise direction. This turns drive gear 292 clockwise and rotates idler 301 counterclockwise. Line feed gear 331 can rotate in a clockwise direction and hence is no longer blocked by detent 303. Accordingly, idler 301 is pulled clear of carriage space gear 305 by spring 304 and rotates the line feed gear 331 in a clockwise direction to afford a line feed operation for the paper in the printing machine.

From the foregoing description, it will be seen that the embodiment of FIGS. 13 and 14 functions in a manner essentially similar to the embodiment of FIGS. 1-12 except that in the high speed printer 220 of FIGS. 13 and 14 the line feed operation for the paper, as well as the carriage return operation, is carried out directly in response to reverse rotation of the carriage drive motor. Thus, the solenoid 121 is not necessary in the embodiment of FIGS. 13 and 14.

We claim

1. In a high speed printer of the kind comprising a carriage movable in predetermined incremental steps along a given path in a character spacing direction from an initial position toward a limit position and movable along said path in a return direction back to said initial position from any position on said path, a carriage drive comprising:

a rotatable drive member;

reversible stepping drive means for rotating said drive member, in incremental steps, in a normal direction and in a reverse direction;

a rotatable driven member, operatively connected to said carriage, for driving said carriage in said character spacing direction in response to rotation of said driven member in a first direction;

clutch means actuatable between an engaged condition and a disengaged condition, coupling said drive member in operative driving relation to said driven member to rotate said driven member in said first direction in response to rotation of said drive member in said normal direction when said clutch is engaged, said clutch means being actuatable to its disengaged condition in response to reverse rotation of said drive member;

and spring return means, connected to said carriage, for moving said carriage in its return direction independently of said drive means upon disengagement of said clutch means from said driven member.

2. A carriage drive for a high speed printer, according to claim 1, in which said clutch means comprises a rotatable idler member mounted on a pivotally movable idler support, said idler support being movable to an engaged position with the idler member coupling the drive member in driving relation to the driven member in response to normal rotation of the drive member, and said idler support being movable to a disengaged position, in which said idler member is free of at least one of said drive and driven members, in response to reverse rotation of the drive member.

3. A carriage drive for a high speed printer according to claim 2, in which the drive member, the idler member, and the driven member are all gears, and in which said idler support comprises a support lever having one end pivotally mounted in coaxial relation to said drive member and connected thereto by a slip coupling that tightens only when said drive member is rotated in its reverse direction, said idler member being rotatably mounted upon the other end of said support lever.

4. A carriage drive for a high speed printer according to claim 3, and further comprising resilient biasing means con-

nected to said idler support for biasing said idler support toward a position in which said idler gear is in meshing engagement with both said drive gear and said driven gear.

5. A carriage drive for a high speed printer, according to claim 3, in which said slip coupling comprises a spiral spring interposed between nested concentric walls of said drive member and said idler support lever and wound in a direction such that the spring tightens upon reverse rotation of said motor to afford a firm coupling between said concentric walls and assure movement of said idler support lever to its disengaged position, and further comprising biasing means normally urging said idler support lever toward its engaged position.

6. A carriage drive for a high speed printer, according to claim 2, and further comprising detent means for limiting reverse rotation of said idler member to a given number of incremental steps whenever said drive means is driven in its reverse direction, and in which return of said idler support to its engaged position requires a corresponding number of incremental steps of rotation of said drive means in its normal direction.

7. A carriage drive for a high speed printer, according to claim 1, in which said drive means comprises a subfractional horsepower electrical stepping motor energized by an electrical stepping signal including one cycle for each incremental step of advance required of said carriage.

8. A carriage drive for a high speed printer, according to claim 1, in which the operational connection between said driven member and said carriage comprises a flexible, belt-like drive connector member, and in which said spring return means comprises a torsion spring operatively connected to said drive connector member.

9. A carriage drive for a high speed printer, according to claim 8, in which said drive connector member is a toothed drive belt and in which said torsion spring has one end connected to a pulley engaged by said belt.

10. A carriage drive for a high speed printer, according to claim 2, and further comprising decelerator means, including an operating member projecting into said carriage path, for engaging and braking said carriage, as said carriage approaches its initial position, and for using the kinetic energy of the returning carriage to hold said carriage in its initial position, without substantial bouncing, once that position is reached.

11. In a high speed printer of the kind comprising a carriage movable along a given path in a character spacing direction from an initial position toward a limit position and movable along said path in a return direction back to said initial position from any position on said path, a carriage drive comprising:

precision drive means, coupled to said carriage, for advancing said carriage along said path in said character spacing direction;

spring return means, coupled to said carriage, for rapidly moving said carriage in its return direction, independently of said drive means, back to said initial position;

a fixed stop for said carriage, at said initial position;

and decelerator means for engaging and braking said carriage, as said carriage approaches its initial position, and for using the kinetic energy of the returning carriage to hold said carriage in its initial position, without substantial bouncing, once that position is reached, said decelerator means comprising:

an operating lever extending into the path of said carriage at a given position;

a flywheel;

and a two-way frictional coupling between said operating lever and said flywheel, such that during its rapid return movement said carriage engages said operating lever at said given position and starts rotation of the flywheel to absorb part of the kinetic energy of the carriage, and continuing rotation of the flywheel causes said lever to press said carriage against said stop.

12. A carriage drive for a high speed printer, according to claim 11 in which said coupling between said operating lever and said flywheel includes a drive gear element mounted on said lever, a driven gear element mounted coaxially with said flywheel, juxtaposed engaged friction members on said flywheel and said driven gear element, and resilient biasing means maintaining said friction members in engagement.

13. In a high speed printer of the kind comprising a carriage movable along a given path in a character spacing direction from an initial position toward a limit position and movable along said path in a return direction back to said initial position from any position on said path, a carriage drive comprising:

drive means, coupled to said carriage, for advancing said carriage along said path in said character spacing direction;

spring return means, coupled to said carriage, for rapidly moving said carriage in its return direction, independently of said drive means, back to said initial position;

a low-inertia carriage-engaging means comprising an operating member projecting into position to be engaged by said carriage on its return movement;

a high-inertia acceleration-resisting means comprising a

flywheel;

a two-way friction coupling between said carriage-engaging means and said acceleration resisting means;

and a fixed stop for interrupting return movement of said carriage at said initial position,

said carriage-engaging means, said acceleration-resisting means and said friction coupling conjointly comprising a free-moving high-inertia decelerator system which intercepts and decelerates said carriage as it approaches its initial position during return movement, limiting the decelerating force applied to the carriage to a predetermined maximum and converting a major portion of the kinetic energy of the moving carriage into heat,

said friction coupling maintaining said operating lever in engagement with said stop, in response to continuing rotation of said flywheel, to prevent bouncing of the carriage.

14. A carriage drive for a high speed printer, according to claim 13, in which said drive means comprises a stepper motor, a drive linkage connecting said stepper motor to said carriage, and a clutch, interposed in said drive linkage, for releasing said carriage for return movement in response to said spring means.

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