May 7, 1968 J. KONKEL 3,381,867

PAPER FEED DRIVE SYSTEM FOR HIGH SPEED PRINTERS

Filed Oct. 14, 1965 3 Sheets-Sheet 1

FIG. 1

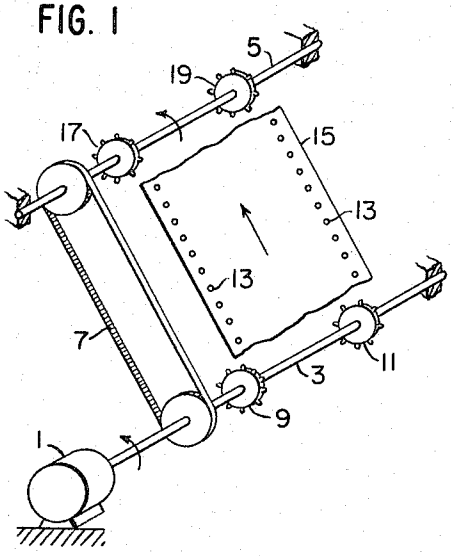
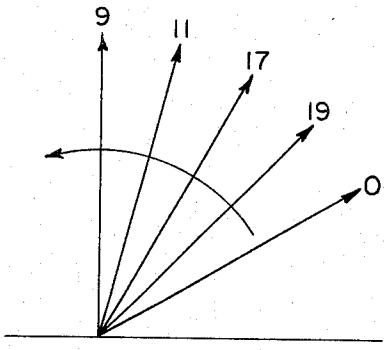


FIG. 2



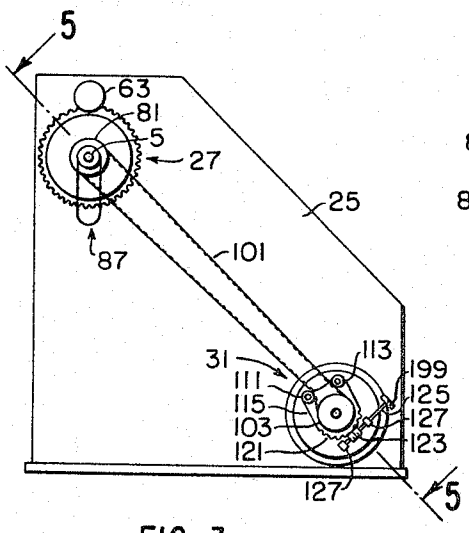


FIG. 3

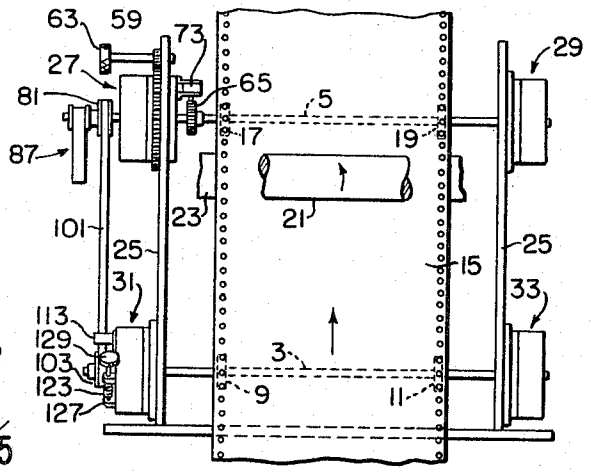


FIG. 4

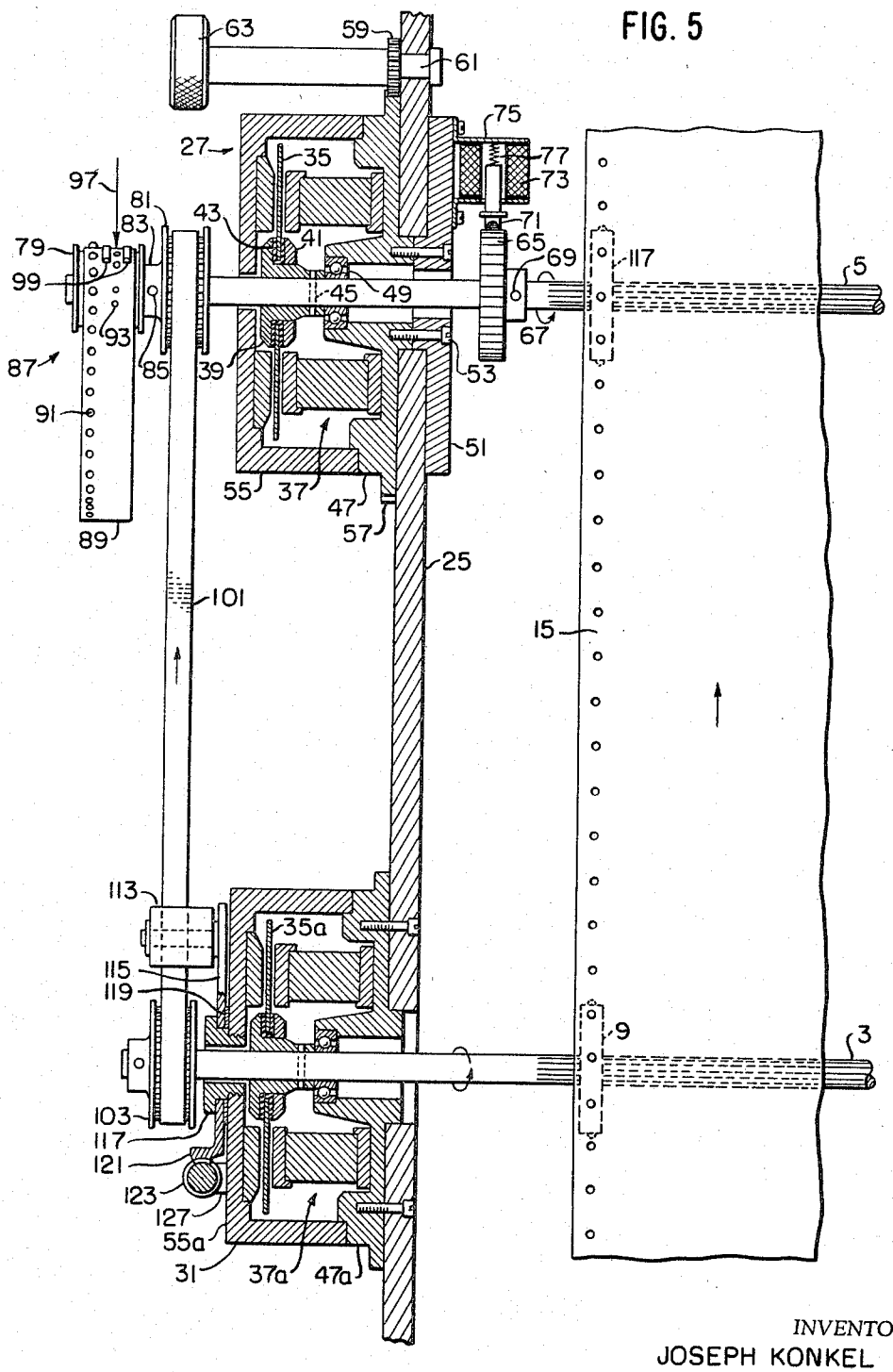
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FIG. 5



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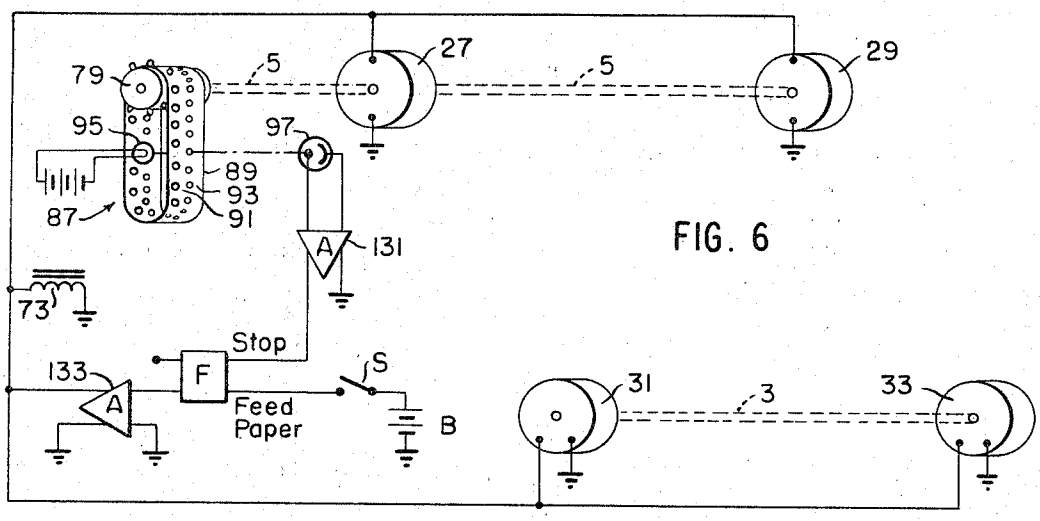


FIG. 6

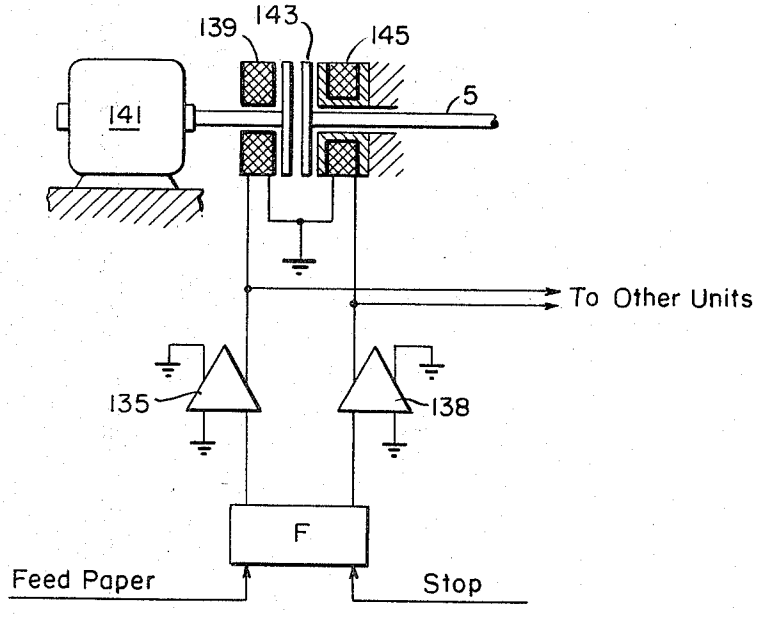


FIG. 7

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PAPER FEED DRIVE SYSTEM FOR HIGH SPEED PRINTERS

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11 Claims. (Cl. 226—9)

ABSTRACT OF THE DISCLOSURE

This invention relates to a paper feed drive indexing mechanism having individual drive motors coupled to opposite ends of a feed-sprocket shaft. The rotation of the motors is controlled by indicia carried by an auxiliary tape which is driven in synchronism with the feed sprocket shaft.

My invention relates to high speed printers, and particularly to a novel paper feed drive mechanism for rapidly and accurately positioning a record sheet with respect to the print station in a high speed printer.

Since the development of modern high speed digital computers, it has continually been a problem that machines are capable of generating information at a more rapid rate than the information can be presented to the operator. High speed printers have been developed for printing out computer outputs at rates up to perhaps two thousand lines per minute. Since the earliest developments of such printers, however, a principal limiting factor in setting the maximum operating rate has been the difficulty of moving the record sheet, commonly a sheet of paper, the succeeding printing positions after each line is printed. The problem is further complicated by the fact that users insist on clean copy with straight lines of print uniformly spaced apart. In order to solve this problem, printers have been developed in which an upper drive shaft is located beyond the print station where a line is printed and a lower drive shaft is located below the print station. Each shaft is provided with means for engaging opposite sides of the record sheet, the latter being perforated for that purpose. The paper engaging means may comprise sprockets, chain tractors, or the like. The upper and lower shafts are connected together by a toothed timing belt, to attempt to keep them in synchronism, and one of the shafts is driven at one end through a relatively massive brake and clutch arrangement by means of a constantly rotating motor. In order to minimize lags of the paper engaging means with respect to each other in response to the force imposed by the driving arrangement, relatively massive parts are employed. The necessity for accelerating these parts very rapidly, so that the paper can be positioned at rates up to 30 times per second, requires large amounts of energy to be supplied to the drive motor, much of which is dissipated in the form of heat. The objects of my invention are to reduce the energy requirements for a paper feed drive mechanism, to make the parts lighter and less expensive, and to facilitate the movement of paper at higher speeds with greater positional accuracy than were formerly attainable.

Briefly, in a paperfeed mechanism in accordance with my invention, each paper-engaging sprocket or tractor is treated as a separate load and provided with its own drive means. The drive means is preferably an electric motor, such as the currently available DC printed circuit motors. However, in accordance with the broader aspects of my invention, a brake and clutch arrangement using a constantly rotating motor of either DC or AC design may be employed. In order to ensure that each of the motors drives its load over the same angle as the others,

means are provided for simultaneously starting and stopping the motors. Additionally, it is preferred to connect the upper and lower shafts of a two-shaft paper feed system with a timing belt. The inclusion of this belt ensures that there will be no cumulative positioning error, and also facilitates the adjustment of the tension of the paper between the paper engaging means and of the position of the paper with respect to the print station.

The apparatus of my invention and its mode of operation will best be understood from the following detailed description, together with the accompanying drawings, of a preferred embodiment thereof.

In the drawings,

FIG. 1 is a schematic sketch of a conventional paper feed arrangement for use in a high speed printer;

FIG. 2 is a diagrammatic sketch illustrating the relative positions assumed by various parts in the apparatus of FIG. 1 during normal operation;

FIG. 3 is an elevational view of a high speed printer incorporating a paper feed drive mechanism in accordance with my invention;

FIG. 4 is a plan view of the apparatus of FIG. 3 with parts broken away;

FIG. 5 is a cross-sectional detailed sketch, with parts shown in cross-section and parts broken away, taken essentially along the line 5—5 in FIG. 3;

FIG. 6 is a schematic wiring diagram of the portion of the apparatus in FIGS. 3 and 4; and

FIG. 7 is a schematic diagram of a modified embodiment of my invention.

Referring first to FIG. 1, conventional paper feed apparatus for a high speed printer is schematically shown, comprising a motor 1 directly driving a lower paper feed shaft 3, and driving and upper paper feed shaft 5 through a toothed timing belt schematically shown at 7. On the lower paper feed shaft are located two paper engaging means, here shown as sprockets 9 and 11 having suitable projections for engaging perforations 13 in the record sheet 15. The upper drive shaft is similarly provided with a pair of paper engaging means 17 and 19. In practice, a clutch and brake arrangement would be located between the motor 1 and the shaft 3, but this conventional apparatus has not been illustrated.

Referring to FIGS. 1 and 2, assume that the motor 1 is started from rest and accelerates the system comprising the shafts 3 and 5 rapidly to a new position. Assuming that both shafts start from a reference angle 0 in FIG. 2, at the end of a period of time in which the sprocket 9 has reached the relative rotational angle illustrated in FIG. 2, the remaining sprockets 11, 17 and 19 will be at the relative angles shown, it being understood that these angles have been grossly exaggerated for purposes of illustration. The lag between the sprocket 9 and the sprocket 11 is due to torsion occurring in the shaft 3. It will be apparent that while this angle can be reduced by making the shaft 3 more massive, to do so increases the weight of the system and thereby increases the mass which must be accelerated. The sprocket 17 will lag the sprocket 9 by an angle which will in general be somewhat greater than the lag between the sprockets 9 and 11, because of the greater length and somewhat greater elasticity of the timing belt 7. The sprocket 19 will lag the sprocket 17 by an angle similar to that by which the sprocket 11 lags the sprocket 9. Since there are forces acting to bring the shafts into angular alignment, there will obviously be vibrations set up, with attendant energy loss and the possibility that the paper will be torn or warped. As indicated above, reducing the vibrations and distortions produced in this way, to a value which is tolerable at speeds up to perhaps 2000 lines per minute, requires relatively massive construction of the moving parts.

Referring now to FIGS. 3 and 4, I have shown a printer incorporating a paper feed drive mechanism in accordance with my invention in which the required masses are minimized and in which the tendency of the paper engaging means to get out of phase is greatly reduced. As shown, the upper drive shaft 5 and the lower drive shaft 3 are arranged in the conventional manner with respect to the print station defined by the location of a character drum 21 on one side of the record sheet 15 and a bank of hammers schematically indicated at 23 on the opposite side. The paper engaging means 9, 11, 17 and 19 are arranged to drive the paper 15 to desired positions with respect to this print station. The shafts 3 and 5 are journalled in a suitable frame 25, and each end of these drive shafts is drivably connected to the rotor of a drive motor. Specifically, drive motors 27 and 29 are connected to the opposite ends of the paper feed shaft 5, and motors 31 and 33 are connected to the opposite ends of the lower drive shaft 3.

Referring now to FIGS. 3, 4 and 5, the motors 27, 29, 31 and 33 may be of any conventional construction, but are preferably printed motors of the type shown and described on pp. 50 through 53 of the March, 1963 issue of Electromechanical Design. As will appear, the stator of the motor 27 is mounted for adjustable rotation in the frame 25, whereas the stators of the motors 29, 31 and 33 are fixed to the frame 25.

Referring now specifically to FIG. 5, the motor 27 comprises an armature consisting of a disc 35 on both sides of which are printed patterns of conductors, not shown, adapted to be energized by brushes, not shown, to produce a field interacting with the field produced by a permanent magnet stator assembly 37 to produce torque in a known manner. The disc 35 is secured to a hub 39 by means such as a nut 41 threaded on the hub 39 and engaging the disc 35 through an intermediate insulating spacing member 43. The hub 43 is secured to the shaft 5 by any conventional means such as a pin 45. The field assembly 37 of the stator of the motor 27 is mounted on a ferromagnetic flange 47 by conventional means, not shown, and the armature is journalled in the flange 47 by means such as a bearing 49. The flange 47 is secured to a mating flange 51 by means such as the bolts 53, these flanges receiving the frame 25 sufficiently freely to allow rotation of the flanges with respect to the frame.

The motor 27 is provided with an outer housing 55 of ferromagnetic material, to serve as a return path for the flux through the armature 35. The housing 55 is secured to the flange 47 by any suitable means, such as bolts or the like.

The flange 47 is provided with teeth 57 around its outer periphery to engage teeth on a gear 59 secured to a shaft 61. The shaft 61 is journalled in the frame 25 and has a knurled knob 63 secured to its outer end to facilitate adjustment of the rotated position of the stator of the motor 27.

The motors 29, 31 and 33 may each be of the same construction, with one exception to be noted, and this construction may be the same as that of the motor 27 except for the variations illustrated for the motor 31. The flange 47*a* for the motors such as 31, corresponding to the flange 47 for the motor 27, is bolted directly to the frame 25, and no teeth such as 57 are provided. The housings for the motors 29 and 33 may be identical with the housing 55 of the motor 27. The housing 55*a* of the motor 31 is modified in a manner to be described.

To provide angular registration of the shafts 3 and 5, a serrated disc 65 provided with a hub portion 67 is secured to the shaft 5 by suitable means such as a pin 69. The disc 65 is provided with a notch for each line increment of motion of the paper 15 over one complete revolution of the shaft 5. In any particular adjusted position of the motor 27, one of the notches in the disc 65 is engaged by a detent 71. The detent 71 is adapted to be released when the coil 73 of a solenoid having a frame 75 is energized, and returned into engagement with the disc 65 when the coil 73 is deenergized. To return the detent, a spring 77 is provided, engaging the detent and the frame 75 of the solenoid. The frame 75 of the solenoid is bolted to the flange 51. As will appear, quite accurate control of the shaft position is possible without the use of the detent, so that the detent is not required to exert any appreciable force on the disc 65, nor to move it over any substantial angle, but merely serves to prevent cumulative drift of the shaft position.

At the outer end of the shaft 5 are carried a pair of sprockets 79 and 81 having a common hub portion 83 secured to the shaft 5 by means such as a pin 85. The sprocket 79 carries a shaft angle transducer 87 for producing signals indicating the angular position of the shaft 5 for purposes of controlling the motors 27, 29, 31 and 33, as will appear. As indicated in FIGS. 5 and 6, the transducer 87 may comprise a coded format tape 89 provided with registering perforations 91 to engage projections on the sprocket 79, and apertures such as 93 for marking predetermined shaft angles. On one side of the format tape is located a suitable source of light such as a lamp 95, and on the other side is located a photocell such as 97. The format tape may be held in engagement with the sprocket 79 by means such as the spring fingers 99, fixed with respect to the housing 27 in any conventional manner, not shown.

Referring to FIGS. 3, 4 and 5, the sprocket 81 carries a timing belt 101 engaging teeth formed in the sprocket, and connected to the shaft 3 by means of a sprocket 103 pinned to the shaft. This timing belt serves to synchronize the shafts and is used to control the tension of paper held between the sprockets on the drive shafts 3 and 5, but is not required to deliver any substantial amount of power, as the control for the motors, to be described, will actuate the shafts 3 and 5 substantially in synchronism without the constraint of the timing belt. If desired, the lower drive motors 31 and 33 can be omitted, depending upon the timing belt to drive the lower shaft in synchronism with the upper shaft.

The timing belt 101 is engaged by a pair of rollers 111 and 113 journalled in a plate 115 pivotally mounted on the housing 55*a* of the motor 31. As shown in FIG. 5, the housing 55*a* is threaded for this purpose to receive a bearing stud 117 yieldably holding the plate 115 in engagement with a washer 119 to permit rotation of the plate 115 about the axis of the shaft 3. Gear teeth 121 are formed on the plate 115 for engagement with a worm 123. The worm 123 is secured to a control shaft 125 journalled in the plate 115, as indicated at 127. A knob 129 is fixed to the shaft 125 to permit controlled manual rotation of the plate 115, whereby the shaft 3 may be rotated with respect to the shaft 5 in a known manner to effect tension control of paper engaged by the sprockets on the shafts 3 and 5.

Referring now to FIG. 6, the photocell 97 is shown connected to the input terminals of a conventional amplifier 131 to cause the amplifier 131 to produce an output pulse each time an aperture 93 in the format tape 89 passes between the lamp 95 and the photocell. The output of the amplifier 131 is applied to the reset terminal of a conventional flip-flop F to reset it to a reference state. The set input terminal of the flip-flop F is connected through a suitable control circuit, here shown as a battery B in series with a switch S, such that when the switch S is closed the flip-flop F will be set to a second state. The logic 1 output terminal of the flip-flop F is connected in the control circuit of a second amplifier 133, of any suitable conventional construction, for supplying operating current to the motors 27, 29, 31 and 33 and the solenoid coil 73, in parallel, when the flip-flop is in its set state. As will be apparent to those skilled in the art, the switch S and battery B would be replaced in practice by an electronic switching apparatus for pro-

ducing a "feed paper" signal at the termination of a print cycle.

It will be apparent to those skilled in the art that in the operation of the apparatus shown in FIGS. 3 through 6, application of a feed paper signal to set the flip-flop F by closure of the switch S will cause the motors **27**, **29**, **31** and **33** to start running in parallel; rotation will continue until the next coded aperture **93** in the format tape **89** passes the lamp **95**. At that time, the flip-flop F will be reset and the motors will stop. Particularly with the use of the printed motor described above, over the short range of angular rotation which is commonly encountered in high speed printers, the single pulse of operating current supplied to the four motors in parallel and terminated at the same time will result in a uniform motion of the paper **15** from one line position to the next. Provision of the timing belt **101** additionally ensures that the shafts **3** and **5** will remain in alignment. As will be apparent to those skilled in the art, the format tape **89** may be coded to cause the paper feed mechanism to advance one line at a time, or, where it is desired for the printing of prescribed forms, may be arranged to allow the paper to advance for any prescribed distance between lines. Additionally, it will be apparent that a bank of photocells such as **97** and corresponding lamps such as **95** could be provided and located transverse to the direction of movement of the tape **89**, and that each angular position could be assigned a code sequence of punched holes so that a positive match to a desired position could be attained.

The operation of the apparatus of FIGS. 3 through 6 will be apparent to those skilled in the art from the above description. Briefly, however, operation is begun by placing a record sheet **15** on the sprockets **9**, **11**, **17** and **19**, whereupon the appropriate tension may be established by adjustment of the knob **129** if necessary. The form positioning knob **63** may then be actuated to rotate the sheet **15** up or down with respect to the print station defined by the print hammers **23** and the print roll **21**. During this operation the detent **71** in FIG. 5 engages the serrated disc **65** and the shafts **3** and **5** are rotated in synchronism by means of the belt **101**. This operation will not appreciably load the detent **71**, since it is carried out manually and at a very slow speed relative to the speeds occurring during paper feeding.

When the form is appropriately positioned on the printer, a conventional printing operation may be carried out, during which the switch S in FIG. 6 is intermittently closed and opened. Each time it is closed, the solenoid coil **73** is energized to release the detent **71**, and the motors **27**, **29**, **31** and **33** are operated in synchronism to advance the shafts **3** and **5**. Since the amount of energy supplied to the motors may be very accurately regulated by electronic means, very precise and rapid position control can be effected. The parts may be made relatively light, and consequently easily accelerated, since each of the motors such as **27** is only required to supply a quarter of the power required to move the paper and the moving parts of the paper feed mechanism. Each motor can consequently be smaller, and itself more easily accelerated and controlled. At the end of each paper advance, the solenoid **73** is released and the detent will engage the disc **65**, correcting any slight drift that may have occurred and preventing cumulative errors in line positioning.

Referring now to FIG. 7, I have illustrated a modified embodiment of my invention in which the four ends of the shafts **3** and **5**, or if desired, the opposite ends of the upper shaft **5** alone, may be controlled. The input signals to the flip-flop F would be provided as illustrated in FIG. 6, and in this instance both of the output terminals of the flip-flop would be employed, each controlling one input circuit of one of two amplifiers **135** and **137**. The output circuit of the amplifier **135** is connected to apply current to the operating coil of an electromagnetic clutch **139**, driven by a suitable conventional constantly rotating motor **141**. The shaft **5**, provided with a suitable armature **143**, is engaged by the clutch **139** with the flip-flop F in its set state. In the reset state of the flip-flop F, the amplifier **137** will apply current to a conventional brake magnet **145** to stop the shaft **5**. Other clutch-brake units would be similarly connected, as schematically indicated in FIG. 7.

While I have described my invention with reference to the specific details of various embodiments thereof, many changes and variations will occur to those skilled in the art upon reading my description, and such can obviously be made without departing from the scope of my invention.

Having thus described my invention, what I claim is:

1. Positioning apparatus, comprising a shaft, an electric drive motor connected to each end of said shaft, a shaft angle transducer connected to said shaft for producing an output signal at each of a selected set of angular positions thereof, bistable circuit means having first and second states, means controlled by said bistable circuit means in its first state for simultaneously applying operating current to each of said motors, means responsive to an applied drive pulse for setting said bistable circuit means to its first state, and means controlled by said shaft angle transducer for setting said bistable circuit means to its second state when the next of said output signals is produced.

2. In a high speed line printer, a paper feed shaft, means fixed on said shaft for engaging opposite sides of a record sheet, an electric drive motor connected to each end of said shaft, each motor being responsive to applied current for driving said shaft in a predetermined direction, a shaft angle transducer connected to said shaft for producing an output signal at each of a selected set of angular positions of said shaft, bistable means settable to first and second states and set by an applied pulse to a first state for simultaneously supplying current to said motors, and means responsive to each of said output signals for setting said bistable means to its second state.

3. In a high speed line printer of the type having an upper paper feed shaft located beyond a print station and a lower paper feed shaft located in advance of the print station, the shafts each having fixed thereon means for drivably engaging opposite sides of a record sheet passing through the print station, the combination comprising, first and second electric drive motors drivably connected to first and second ends of one of said shafts, respectively, and timing belt means drivably connecting said upper shaft to said lower shaft.

4. The apparatus of claim **3**, further comprising a shaft angle transducer connected to one of said shafts for producing an output signal at each of a selected set of angular positions thereof, bistable means having first and second states and set by an applied pulse to a first state for simultaneously supplying current to said motors, and means responsive to each of said output signals for setting said bistable means to its second state.

5. In a high speed printer of the type having an upper paper feed shaft located beyond a print station and a lower paper feed shaft located in advance of the print station, the shafts each having fixed thereon means for drivably engaging opposite sides of a record sheet passing through the print station, the combination comprising, four electric drive motors, one drivably connected to each end of each of said shafts, and means for simultaneously starting and stopping said motors to drive the shafts through a predetermined common angle.

6. The apparatus of claim **5**, further comprising a timing belt drivably connecting said shafts to maintain them in a predetermined relative relation.

7. In a high speed printer of the type having an upper paper feed shaft located beyond a print station and a lower paper feed shaft located in advance of the print station, the shafts each having fixed thereon means for

drivably engaging opposite sides of a record sheet passing through the print station, the combination comprising, first and second electric motors drivably connected to opposite ends of one of said shafts, means for simultaneously starting and stopping said motors to drive said shaft through a predetermined angle, a timing belt drivably connecting said shafts, and means for adjusting said timing belt to rotate one of said shafts with respect to the other.

8. In a high speed printer, a frame, a first paper feed shaft and a second paper feed shaft journalled in said frame for rotation about spaced parallel axes, the shafts each having fixed thereon means for drivably engaging opposite sides of a record sheet, first and second electric motors having rotors drivably connected to opposite ends of said first shaft, said first motor having a stator adjustably mounted on said frame for rotation about the axis of rotation of said first shaft, said second motor having a stator fixed to said frame, detent means for releasably securing said first shaft to the stator of said first motor, a timing belt drivably connecting said shafts, and means for adjusting said timing belt to rotate one of said shafts with respect to the other.

9. In a high speed printer, a frame, first and second paper feed shafts journalled in said frame for rotation about spaced axes, said shafts each having fixed thereon means for drivably engaging opposite sides of a record sheet, first and second electric motors having rotors connected to opposite ends of said first shaft, third and fourth motors having rotors connected to opposite ends of said

second shaft, said motors having stators mounted on said frame, a shaft angle transducer connected to one of said shafts for producing an output signal at each of a selected set of angular positions thereof, bistable means having first and second states and set by an applied pulse to a first state for simultaneously supplying current to said motors, and means responsive to each of said output signals for setting said bistable means to its second state.

10. The apparatus of claim **9**, further comprising a timing belt interconnecting said shafts to ensure synchronous rotation thereof.

11. The apparatus of claim **9**, in which the stator of said first motor is adjustably mounted on said frame for rotation about the axis of rotation of said first shaft and the stators of the rest of said motors are fixedly mounted on said frame, and further comprising releasable detent means actuable to hold said first shaft to the stator of said first motor, and means controlled by said bistable means in its first state for releasing said detent means.

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