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The seal of The Patent Office, London. It is a circular emblem featuring a central shield with a crown on top, flanked by two lions. The shield is surrounded by a wreath. The outer ring of the seal contains the text "THE PATENT OFFICE" at the top and "LONDON" at the bottom. Below the shield, there is a motto scroll with the text "DIEU ET MON DROIT".

(71) We, SCI SYSTEMS, INC., of 8620 South Memorial Parkway, Huntsville, Alabama 35802, United States of America, a corporation organized and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to rotary electrical graphic devices for image recording and printing and particularly to rotary printing.

The present case is divided out of British Patent Application No. 36901/76 (Serial No. 1566281) which describes and claims rotary printers and contains subject matter which is common with the present case. British Patent Applications Nos., 7904365 and 7904367 (Serial Nos. 1566282 and 1566284) have also been divided from British Patent Application No. 36901/76 (Serial No. 1566281) and all contain subject matter common with the present case.

The present invention consists in a rotary electrical graphic device including a substantially cylindrical platen, a rotor mounted to rotate within the platen cylinder, a plurality of styli secured to said rotor, drive means for turning said rotor, record material feed means coupled to said drive means for feeding a strip of said material through said platen in contact with its inside surface with the styli containing said material at locations where the material is in contact with said platen and at a speed which is directly proportional to the speed of said rotor, and means for electrically energizing each of said styli.

In order that the present invention may be more readily understood, two embodiments thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a front perspective view of a printer constructed in accordance with the present invention;

Figure 2 is a rear perspective view of the printer shown in Figure 1, with the paper guide raised, and with some of the paper removed;

Figure 3 shows a section of the paper recording strip used in the printer of Figure 1 and bearing a reproduction of printing actually produced by the printer;

Figure 4 is an exploded front perspective view of the printer shown in Figure 1;

Figure 4a is a similar view of a drive gearing arrangement for a paper feed roller.

Figure 5 is a cross-sectional view taken along line 5-5 of Figure 1;

Figure 6 is an elevation view of the rotor of the device of Figure 1 taken in the direction of line 6-6 of Figure 5;

Figure 7 is an elevation view of the timing disc of the device shown in Figures 1 through 5, and is partially schematic;

Figure 8 is a set of waveform diagrams demonstrating the operation of the timing disc and associated electronic circuitry;

Figures 9 and 10 comprise the electrical control circuit of the printer shown in Figures 1 through 5;

Figures 11 and 12 are partially schematic elevation views of a component of the printer, with the component being shown in two different operating positions in the two figures;

Figure 13 is a plan view, partially schematic, illustrating another embodiment of the invention;

Figure 14 is a side elevation view, partly in cross-section, of another embodiment of the

printer of the present invention;

Figure 15 is an elevation view, partly cross-sectional, taken along line 15-15 of Figure 14;

Figure 16 is another elevation view of the rotor shown in Figures 14 and 15;

Figure 17 is a side elevation view of one of the print heads of the printer shown in Figures 14, 15 and 16;

Figure 18 is an end elevation view of the print head shown in Figure 17; and

Figure 19 is a cross-sectional, broken-away view of a portion of the Figure 14 structure taken along line 19-19 of Figure 14.

Figures 1 and 2 show an embodiment of a printer constructed in accordance with the present invention. The printer 20 includes a base plate 22, a cylindrical housing 24, a cylindrical sleeve 26 which is used as a platen, a rotor 28 in the form of a disc mounted on a shaft 48 so as to rotate in the sleeve 26, and a drive motor 30 for rotating the rotor 28. A timing disc 54 (Figure 2) for timing the printing also is mounted on the shaft 48.

A recording medium in the form of electrical discharge-sensitive paper 36 is stored in a roll 34 contained in a dispenser 32. The paper 36 passes upwardly from the roll 34 over a straight guide bar 35 towards a curved paper guide 38. The guide 38 is hinged to the outer surface of the housing 24 at 40 so that it can be raised easily in the manner shown in Figure 2. As it is shown in Figure 1, a latch 42 holds the guide 38 down when the printer is in operation.

The front and rear edges of the guide 38 act as guide members which act to guide the edges of the paper 36.

Referring to Figure 2, a drive roller 56 is provided which pulls the paper from the roll 34, drawing it through the curved guide 38 so that the paper forms an arc, and feeds the paper through the sleeve 26 near its upper most inside surface. After the printing has been formed on the undersurface of the paper 36, the paper emerges from the left edge of the sleeve 26 as shown in Figure 1. A paper tear ring 46 is provided at the left edge of the sleeve 26. The ring 46 has a serrated upper edge 47 to permit a length of the paper strip to be torn off easily.

The undersurface (that is, the concave surface) of the paper strip 36 is coated first with a dark material, and then with a light-colored material such as aluminum or zinc oxide which can be eroded or vaporized away by an electrical discharge or spark. The rotor 28 has three stylus heads 62, 64 and 66 each with five parallel equidistant axially-spaced styli 68 (see Figures 5 and 6).

As it will be explained in greater detail below, the paper feed roller 56 and the rotor 28 are driven continuously by the drive motor 30. The styli are selectively energized so as to form images on the underside of the paper by the formation of dots in a five dot by seven dot matrix.

An example of printing produced by the printer 20 is shown in Figure 3. Each stylus head has five wires, which is enough to produce all the dots for the horizontal portions of characters to be printed. Thus, each time one of the stylus heads passes over the recording paper, it will produce at least one printed character.

It is preferred that the words be printed on the strip as shown in Figure 3; that is, in the longitudinal direction indicated by the arrow 31. Furthermore, when several lines of text are to be printed, the data is stored in a memory in the device and is read out so that each stylus head will print an entire vertical column of characters, one character from each of the lines. For example, the first column A of characters in Figure 3 was printed by a single pass of a single stylus head; the column B was printed by a single pass of a second stylus head, and column C was printed by a single pass of a third stylus head. Since there are three stylus heads, three columns of characters are printed per revolution of the rotor. Thus, the number of characters per revolution which the device will print is equal to three times the number of lines being printed.

Of course, it also is possible to form words in a vertical direction instead of in the horizontal direction shown in Figure 3. The speed capabilities of the printer when operating in such a mode are comparable with those in the other mode.

The printer 20 now will be described in detail.

Now referring to Figures 4 and 5, the drive system of the printer 20 includes the shaft 48 and the drive motor 30, both of which already have been described. The motor 30 is mounted on an end plate 70 for the housing 24 by means of screws 80. To the output shaft 76 of the motor 30 is secured a toothed drive wheel 78 which drives a toothed-timing belt 50 (see Figures 2 and 4) to drive large toothed wheel 52 which is secured to the shaft 48. The sizes of the wheels 78 and 52 are such as to produce a speed reduction of four to one. The timing disc 54 is secured to the wheel 52 and thus is secured to the shaft 48.

The shaft 48 is mounted in ball bearings 72 in the end plate 70, and a retainer 74 is secured to the right end of the shaft. (See Figure 5). Another end plate 88 is provided at the opposite end of the housing 24. The shaft rotates in ball bearings 92 in the end plate 88, and is retained by a retainer 108 secured to the shaft.

The rotor 28 is mounted on a spacer 110 (see Figure 4 as well as Figure 5) by means of

screws, and the spacer is similarly attached at its other end to a slip-ring disc 104 which abuts against the retainer 108. The spacer, slip-ring, and rotor 128 are held against the retainer 108 by means of a threaded nut 114 which screws onto threads 49 (Figure 4) on the left end of the shaft 48. Thus, the rotor 28, the spacer 110, the slip-ring disc 104, the gear wheel 52 and the timing disc 54 all rotate together at the same speed.

The rubber paper feed roller 56 is driven by gearing coupling it to the shaft 48. As it is shown in Figure 4a and 5, the roller 56 is rotatably mounted on a shaft 96 which is secured in an upper extension 89 (See Figure 4a) of the end plate 88. A slot 91 is provided through which the upper surface of the roller 56 extends.

A lower extension 90 of the end plate 88 forms the bearing support for a shaft 84 to which is secured a worm gear 86 which meshes with a worm 82 secured to the shaft 48. This combination drives a bevel gear 92 which meshes with another bevel gear 94 on the shaft 96 which drives the paper feed roller 56 at a speed substantially slower than that of the rotor 28.

The feed roller 56 mates with an idler roller 98 which is mounted on a shaft 100 in the curved paper guide 38. A cover 102 fits over the idler roller 100 to protect it.

As it can be seen in Figure 5, the recording paper 36 is pinched tightly between the two rubber rollers 56 and 98 so that the rotation of the roller 56 will pull the paper through the printer substantially without any slippage.

Figure 10 shows schematically the electrical circuit formed when a spark is formed between a stylus 68 and the paper 36. The conductive under-surface 39 of the preferred recording paper must be connected to the return terminal of the voltage supply 69 which is connected to the stylus 68 in order to produce electrical discharges. Since that return terminal is grounded, the undersurface of the paper must be grounded.

This is accomplished by a means of a grounding device which is shown in Figures 2, 4 and 5. The grounding device consists of a helical conductive spring 58 which is wound around a curved metal rod 60 which is secured to the end plate 70 in the manner shown in Figure 4 and which is connected to ground. The ends of the spring 58 are held in place by means of retaining rings 61.

As it is shown in Figure 5, the rod 60 curves forwardly as well as into an arc so that it fits underneath the right edge of the cover 38. The upper portion of the coils of the spring resiliently press against the underside of the paper 36 and force it upwardly against the guide 38. The many coils of the spring provide numerous relatively closely spaced contacts to make good grounding contact with the undersurface of the paper.

This combination ground connection and paper tensioning means also serves a third function; that of helping to shape the paper into an arc so that it will pass easily through the guide 38.

As it is shown in Figures 1, 2, 4 and 5, the paper roll 34 is stored on a spindle 120 whose ends fit into slots 118 in a pair of end plates 122 of the dispenser 32. The plates 122 are secured to the base plate 22 of the printer. The friction created by the various components of the dispenser tends to prevent over-run of the paper feed roll after paper feeding has stopped.

As it is most readily apparent in Figure 5, the bar or roller 35 serves the function of causing the paper coming from the roll 34 to be bent through a substantial angle before passing on towards the printer. However, the bar always delivers the paper at approximately the same height to the printer, which would not be the case if the paper were pulled directly from the roll 34. Substantial movement of the dispensing point is undesirable in that it tends to cause bunching or wrinkling of the paper and thus prevents smooth feeding of the paper. Therefore, the dispenser 32 described dispenses the paper strip to the printer uniformly and smoothly.

Figure 6 shows the construction of the rotor 28 and the positions of its three stylus heads 62, 64 and 66. Figure 6 is a partially schematic view of the rotor 28, taken in the direction of line 6-6 of Figure 5, with the spacer 110 and other elements omitted.

As it can be seen in Figure 6, the points of contact between the styli 68 and the circle 125 which represents the internal surface of the platen sleeve 26, are indicated by reference numerals 119, 121, and 123. The styli 68 are mounted in a solid epoxy resin base which is secured to a bracket 128 which is mounted on the rotor 28. The bracket 128 has a curved slot 130 with a screw 132 to allow the stylus head to be moved outwardly or inwardly to increase or decrease the pressure of the styli on the platen or the paper on the platen.

As it can be seen in Figure 6, the angle between the styli and the radius lines extending through the points 119, 121 and 123, is approximately 70°. The angle formed between the styli 68 and the tangent line 127 at point 119 therefore is 20°. Thus, the styli travel over the platen and the paper at an angle substantially less than perpendicular. This makes for smoother operation of the mechanism and reduces the likelihood of the styli tearing the paper when the styli cross over from the platen onto the edge of the paper.

Referring again to Figure 5, it can be seen that the platen sleeve 26 is of a diameter substantially larger than that of the housing 24. This is necessary so that the paper 36 will enter the inside surface of the platen sleeve. The lower two-thirds 116 of the rear edge of the

sleeve 26 is of a smaller diameter so that it will fit onto the flange 93 of the end plate 88 where it is fastened in place by means of three screws (not shown).

The paper tear ring 46 is fitted into a recess 95 in the inside surface of the front edge of sleeve 26.

5 As it also is apparent from Figure 5, each of the stylus heads 62, 64 and 66 is connected to terminals at the rear of the slip-ring board 104 by means of wires 112 (also see Figure 9). The terminals connect through the board 104 to the slip-rings on the other side of the board 104. It also should be noted that the stylus heads 62 and 64 are shown in Figure 5 rotated from their actual positions so that they can be illustrated more clearly.

10 The timing of the formation of dots by the styli is important to the accurate printing of characters and other images. Referring now to Figures 2, 4, 5 and 7, this timing function is provided by means of the transparent disc 54 which has a series of thin opaque black lines 166 (Figure 7) and a single wide black line 168 applied to the disc. Ideally, the three sensors A, B and C would be 120° apart from one another, as are the three stylus heads 62, 64 and 66. However, the construction of the housing 24 and the paper guide 38 does not permit this. Because of such constructional restraints, sensors A and C are placed 180° apart from one another, and sensors A and B are placed 60° apart. Sensor B is fixed in position. However, sensors A and C are movable circumferentially with respect to the disc 54 so as to adjust the timing of the start and stop of printing by the stylus heads relative to one another. This makes it relatively easy to make the initial head alignment, and also makes it possible to easily adjust for uneven wear of the styli and other causes of misalignment of the printing without moving the stylus heads. This avoids unbalancing the rotor and makes the adjustment process quite simple.

Referring to Figures 4, 11 and 12, as well as Figure 7, sensor B, the fixed sensor, includes a detector structure 146 fastened to a mounting plate 148. The detector structure 146 includes a U-shaped housing, one arm of which includes a small light-emitting diode (LED) 153 (Figure 11) which shines its light towards the other arm which contains a small photo-transistor 155 to detect the light. A mask (not shown) comprising a small piece of film which is opaque except for a small thin slit covers the photo-transistor so as to admit only the light which falls on the thin slit.

The detector 146 of sensor B is inserted through a hole 138 in the housing 24 and is secured in place after the disc 54 has been mounted in the housing. The two arms of detector 146 fit around the edge of the disc so that the light from the LED shines through the disc in the area where the markings 166 and 168 are located and is detected by the photo-transistor.

Each of the other sensors A and C also includes an identical detector 146. The detector 146 in each sensor A and C is mounted on an L-shaped bracket 154 which is pivotably connected at 152 to a mounting bracket 150. The bracket 154 has a long arm with a longitudinal groove 156.

Still referring to Figures 4, 11 and 12, two adjustment cam devices 158 and 160 are provided. Each has a body which is fitted rotatably into a hole in the end plate 70 of the housing 24 and has a slotted head which permits the device to be turned with a screwdriver. Each device 158 and 160 also has an eccentrically-mounted pin 162 or 164. As it is shown in Figures 11 and 12, the pin 162 or 164 fits into the groove 156. As the head of the cam device 158 or 160 is rotated, the arm of the bracket 154 is raised upwardly or lowered about the pivot point 152 so as to change the location at which the detector senses the lines 166 and 168. The pivot points 152 are shown schematically in Figure 7.

The detailed operation of the disc 54 and the sensors A, B and C in timing the printing of the printer will be explained in detail in connection with Figures 8 through 10. However, in general, each of the thin, closely-spaced lines 166 times the placement of one dot (or one row of up to five dots), and the wide pulse mark 168 serves as a reference mark. Very precise adjustments in the printing placements can be made by use of the cams 158 and 160 to move slightly the location of either or both of the sensors A and C relative to the sensor B so as to change the relative starting and stopping times for printing produced by the stylus heads.

Figure 9 shows the electrical control circuit for the printer 20. The drive motor 30 is shown in the lower left hand corner of Figure 9, and the styli 68 are shown in the upper right-hand corner of the drawing. The slip-ring disc 104, the brushes 106 contacting the slip-rings and the wires 112 leading from the slip-rings to the styli also are shown in the upper right hand corner. It is evident from Figure 9 that each of the slip-rings is continuous so that each of the brushes 106 continuously is in contact with three styli, one from each of the three stylus heads.

The position of each such stylus is the same in each of the heads. That is, the outermost brush is connected to the first stylus in each head; the next brush to the second stylus, and so forth. This means that the styli in all three heads (labeled groups A, B and C in Figure 9) are energized simultaneously. Therefore, the paper strip 36 should not extend more than one-third of the circumference of the platen 26. Otherwise, extraneous printing will be done on the strip. Of course, if the use of a wider strip is desired, then the styli can be energized

selectively by means of segmented slip-rings.

D.C. is supplied throughout the control circuit by either of D.C. power supply, if 117 volts 60 Hz power is the available source, or from a battery.

5 In the central upper portion of Figure 9 is shown a memory 200 consisting of six 480 bit shift-registers. Connected to the output of memory 200 is an ROM code converter 202 5 commonly called a "character generator", which converts character identification signals from the memory 200 into corresponding dot matrix signals appearing on five output lines 203. The dot matrix signals are adapted to enable selected ones of the five styli which are in 10 contact with the paper strip to be energized so as to form one row of dots in a particular character to be printed. 10

The code converter 202 is addressed by means of three input leads 264,266 and 268 in order to produce on the output lines 203 successively the information to form seven successive rows of dots for a given character, thus enabling the printing of the character in 5x7 dot matrix form. This procedure will be described in greater detail below. 15

15 The memory 200 has a capacity sufficient to store characters for twelve lines of text, each line being forty characters long. By the addition of more shift registers, the storage capacity of the memory 200 can be increased. With a paper strip width of four inches and characters approximately 3/16th inch high, and with minimum spacing between lines, up to twenty-four 20 lines can be printed across the paper strip. The lines can be made about as long as one desires, if one is willing to add the necessary storage capacity to the memory. In fact, if the characters are printed in a single line, and if a "FIFO" memory is used instead of the memory 200, the line can have a virtually unlimited length. 20

Data is applied to the six input lines 204 to the memory 200. A memory control circuit 206 is provided for reading and writing to and from the memory 200. A high frequency clock signal (e.g. 1 M Hz) is applied over input line 226 to one input of a NAND gate 228. Strobe pulses are applied, at a somewhat lower frequency, over another input line 216. The strobe pulses are delivered to one input of a gate 218. During data entry, a D-type flip-flop 236 (lower left-hand corner of Figure 9) is in the reset condition in which a signal appears on output Q and none appears on the output Q. The "low" signal on Q enables gate 218 which 30 delivers strobe pulses through another gate 220 and an AND gate 222 over a read/write line 224 to the memory 200. The strobe pulses cause data to be entered on the common data entry line 225 to the shift registers in the memory. 25

When the flip-flop 236 is reset, the Q signal from flip-flop 236 is applied over a line 244 to inhibit a gate 219 to prevent the reading of data through that gate. 35

Simultaneously with the read-in of data to the memory 200, the output of gate 222 is delivered over line 230 to the clock input of another shift register 232 which also has a storage capacity of 480 bits and is identical to the shift registers in the memory of 200. The shift register 232 is used as a detection device to detect when the memory 200 is full, and to signal the start of the printing operation. 40

When the shift register 232 is full, it sends out an output signal over line 234 to the clock input of the flip-flop 236. This "sets" the flip-flop and creates a signal on the Q output line which is sent over line 238 to a motor drive circuit 208, which is a semi-conductor relay which completes the circuit to the drive motor 30 and starts it running. 40

The change of flip-flop 236 to the "set" condition enables gate 219 and thus makes it possible to read data out of the memory during printing, as it will be described below. Also, gate 218 is disabled by the signal on Q, so that data no longer can be written into the memory from the input lines 204. 45

The operation of the flip-flop 236 also causes a change of state on its Q lead, and this actuates a margin counter circuit. A counter 246 counts two "column sync" signals representing two revolutions of the timing disc 54 (not shown in Figure 9) before it permits the printer to start printing in order to provide a definite unprinted margin on the paper between the matter to be printed and the cut end of the paper strip. 50

At the lower right-hand edge of Figure 9 are shown the three sensors A, B and C shown in Figures 4 and 7 which detect the narrow timing marks 166 and the wide timing mark 168 on the spinning disc 54. Included in the detectors A, B and C shown in Figure 9 may be amplifiers and Schmitt trigger circuits for the amplification and wave-shaping of the pulses from the detectors. 55

The "column sync" signals shown in the waveform diagrams of Figure 8 are the ones that are counted by the margin counter. These signals are developed in the following manner. A column sync counter 212 is provided. It includes two J-K type flip-flops 300 and 302. Flip-flop 302 receives the signal from the C sensor on its clock input, and both flip-flops 300 and 302 receive the B sensor signal on their "clear" leads. 60

Referring now to Figure 7 of the drawings, the disc 54 rotates counter-clockwise. The sensors A, B and C produce signals when a transparent portion of the disc 54 is between the LED and the photo-transistor, allowing light to reach the latter. Therefore, whenever a 65

transparent area of the disc 54 is opposite the B sensor, the "clear" input leads of the flip-flops 302 and 300 are driven low so as to reset the column sync counter 212. When the wide mark 168 (2.5 times as wide as any of the marks 166) passes through the sensor B, this temporarily removes the "clear" signal from the flip-flops 300 and 302, and enables them to count pulses received from the sensor C, which now senses the narrow marks 166. Although it might seem that the thin marks 166 are ending at the time the wide mark 168 is detected by sensor B, this is not so because the wide mark 163 is 64.1° from the forward end of the train of marks 166, whereas sensor B nominally is only 60° from sensor A. Therefore, sensor C then is 220° clockwise away from sensor B, and the end of the thin marks 166 is 224.1° away, and there still are several marks 166 left to pass through sensor C. Thus, the counter counts up to two before the wide pulse 168 ends and the counter again is cleared. This produces an output pulse on Q of flip-flop 300. This pulse is the "column sync" signal shown in Figure 8 and appearing on line 248 of Figure 9.

After the wide pulse passes sensor B, but before the thin lines reach sensor B, the counter remains cleared, and no "column sync" signal is produced. After the thin lines 166 reach sensor B, and also later when both sensors B and C sense the thin lines, the counter 212 is reset once for every transparent space between thin lines, and cannot, therefore, count to two and cannot produce a "column sync" signal. As a result, the "column sync" signal is produced only once per revolution of the disc 54, at the time when the wide mark 168 passes through sensor B.

As it has been noted above, the "column sync" signals are delivered over line 248 to the margin counter 246 which counts two of the signals. The counter 246 then delivers an output signal over line 250 to start the printing operation.

Referring to the lower central portion of Figure 9, the signal on line 250 of the margin counter 246 is delivered to the clock input of another D-type flip-flop 251 which changes state and develops a signal on its Q output line. This signal is supplied over line 254 to the margin counter to inhibit it, and also is supplied over line 252 as a "start" signal to a print-enabling flip-flop 254.

Flip-flop 254 is a D-type flip-flop which is clocked by signals applied to its clock lead 253 from an AND gate 290 which is in the right-central portion of Figure 9. AND gate 290 receives an enabling input on its lower lead, and is enabled by pulses from the A sensor received over line 298. This, in effect, sends the pulses from the A sensor through to the clock input of the flip-flop 254. Thus, the first of the pulses developed by the thin lines 166 on the code disc in the A sensor, together with the "start" signal on line 252, causes a change of state in the flip-flop 254. The subsequent clock pulses from the A sensor also time the later operation of the flip-flop 254. This operation of flip-flop 254 changes the state of the Q output line 256 and the Q output line 274. Simultaneously, the "high" signal on line 256 is applied to one input of another NAND gate 260 whose other input also is high due to being connected to the Q output of another D type flip-flop 258, which is "cleared" at this time.

The output of gate 260 enables the row counter 262 whose function is to count the rows of dots being printed, as well as the spaces in-between lines of characters; to address the ROM code converter 202 over address lines 264, 266 and 268 and cause it to deliver its information through AND gates 272 and amplifiers 314 to the brushes 106 and then to the styli 68. Of course, none of the AND gates 272 will produce a proper output signal unless both of its inputs are in the same state.

One of the inputs of each of the gates 272 is connected to the output of a three-input positive NOR gate 270. The output of gate 270 enables each of the AND gates 272 when the signal on each of input leads (274 and 276) is in the proper state. The signal on line 274 is in the proper state whenever flip-flop 254 is "set" in order to enable printing. Lead 276 is connected to one output terminal 284 of a multiplexer circuit 282 (in the lower right hand portion of Figure 9) which, as it will be explained further below, always receives the pulses produced by the thin lines 166 in the sensors A, B and C. Thus, the gate 270 is enabled repeatedly by the timing pulses produced by the thin lines 166, but only during the short duration of those pulses.

The timing pulses also are delivered from line 284 to the row counter 262 over a line 263. The row counter counts the time pulses and thus steps through its addressing routine and counts the number of rows being printed. Since there are seven dots vertically in each character, the row counter steps through seven pulses, repeatedly changing the combination of outputs on lines 264, 266 and 268 to sequentially address the ROM code converter 202.

On the eight count line 271 of the row counter goes "high". This inhibits the gate 270 and sends an enabling signal over the "clear" line 277 to enable flip-flop 258. Flip-flop 258 does not actually change its state at this time because it is a "D" type device which requires a clock pulse on the clock input to enable it to change. The signal on line 271 also is sent to the line counter 278 to advance it by one count.

The clock input line 257 of the flip-flop 258 actually can be connected to either line 264 or

268 in order to select the spacing between lines of characters. Line 264 is energized when the counter 262 counts up to two, and line 268 is energized when the counter 262 counts to five.

Assuming a line spacing of two has been selected by connecting line 257 to line 264, on the ninth count by the row counter 262, line 264 goes high, and this sets flip-flop 258. If a line

spacing of five is selected, the same action takes place at a count of twelve instead of nine. When flip-flop 258 is set, its Q output goes high and delivers a signal to activate a one-shot multivibrator 261 in the memory control circuit 206 in the upper left portion of Figure 9. The one-shot multi-vibrator produces a pulse which is delivered through gates 219, 220 and 222 to read/write line 224 to read out from memory 200 the information for another character. It should be noted that the information for the first character already appeared on the output leads of the memory 200 because that was the first information that was stored in the memory 200.

The setting of flip-flop 258 causes its Q output to go low, which causes the output of gate 260 to go high and reset all of the outputs of the row counter 262 to zero. The resulting low signal on lines 271 and 277 resets flip-flop 258 and again enables gate 270 to permit the next character to be printed.

The row counter 262 now starts anew to count timing pulses received over the line 263, and the printing of the next character in the column is started. The next character is printed in the same manner as the first character, and the process is repeated until a character has been printed in each of the twelve or twenty-four lines in which characters are to be printed. Thus one column of characters has been completed.

The signal on output lead 271 from the row counter 262 also is delivered to the line counter 278 which counts the number of lines which have been printed in any pass of a print head over the record strip. Two different connections are provided to the line counter 278, one enabling the internal circuitry to count up to twelve lines, the other enabling it to count up to twenty-four lines, at the option of the user.

Assuming that twelve lines are to be printed, after the twelfth character has been printed by a particular print head, the line counter 278 delivers an output signal over line 280 to an AND gate 282 which also receives an input from flip-flop 236 over line 240 so that the flip-flop 254 now is cleared. This disables the printer until it is time to start the next vertical column of characters when the next print head is in position to start printing.

The dot timing circuit 210 includes, in addition to the multiplexer 282 and the column sync counter 212, a data select counter 214 and a divide-by-117 counter 288.

The multiplexer 282 connects different input signals to the output leads 284 and 286 depending upon the state of the input lines 291 and 292. The following table describes the operation of the multiplexer:

TRUTH TABLE FOR MULTIPLEXER 282

	291	292	284	286	Function Permitted
(1)	0	0	A	B	Print Column A
(2)	1	0	B	C	Print Column B
(3)	0	1	C	—	Print Column C
					Column Sync Signal Resets to Condition (1)

The data select counter 214 includes a pair of J-K type flip-flops 304 and 306. When the first pulse from the divide-by-117 counter 288 changes the state of flip-flop 304, this changes the data at the output lines 284 and 286 in accordance with the above table. When the next pulse is received from the circuit 288, the state of the second flip-flop 306 is changed, and data on lines 284 and 286 change again in accordance with the table. In this way, first the A signals then the B signals and then the C signals are delivered to the circuit to control the printing.

Referring now to Figure 8, the "column sync" signal occurs at time t_0 , and the sensor timing signals start shortly thereafter, at time t_1 . Referring now particularly to the "B" sensor waveform in Figure 8, it can be seen that the B sensor starts producing timing pulses at time t_2 .

Referring again to Figure 9, the pulses from sensor B are delivered over output lead 286 of the multiplexer to the divide-by-117 counter 288. Printing by the "A" stylus head ends at t_3 (Figure 8) when the line counter clears the print-enable flip-flop 254. When the counter 288 has counted 117 pulses (one-third of the 351 pulses produced by the thin marks 166 on the disc) the counter 288 produces an output signal which is delivered to one input of an AND gate 294 whose other input is connected to the Q line of flip-flop 300. Thus, AND gate 294 is

enabled and sends a signal over line 296 to clear the line counter 278. This removes the output from the line counter on line 280 and thereby disables AND gate 282 and causes the print-enable flip-flop 254 to change state and start the "B" print head to printing another column of characters. This occurs at time t_4 , a short time after t_3 .

5 From time t_4 to t_6 , the "B" stylus head prints characters. At t_6 , the line counter again operates to stop the printing. In the meantime, timing pulses from the "C" sensor have been delivered to the counter 288 since t_5 . When counter 288 again produces an output after having counted 117 pulses from sensor C, the third stylus head is enabled to start printing at t_7 , until the line counter stops the printing at t_8 . Then the column sync pulse occurs again at t_6 and the printing process is repeated again for another revolution of the rotor 28. This is repeated over and over again until all of the information in the memory 200 has been read out and printed. 10

During the readout of information from the memory 200, the shift register 232 shifts the same number of times as each of the shift registers in the memory. When register 232 is full, a circuit (not shown) is provided which delivers a pulse over line 234 to return flip-flop 236 to its initial state, de-energize the motor drive circuit 208, and stop the motor. This same circuit also resets any of the shift registers or flip-flops which have not already been reset, in order to prepare the circuit for the next printing job. 15

If it is desired to repeat the same printing job to make duplicate copies of the text, this can be accomplished simply as follows. Prior to loading the memory, the "R strobe" input to the shift register 232 and the "R" input to the shift registers in the memory 200 are connected together and to a low signal source. The shift registers are of a type in which this causes the data to be re-circulated and re-stored in the shift registers of the memory 200 instead of being destructively read out. The same is true for the shift register 232. Thus, in this mode of operation, the printer automatically will print the same text matter again and again, as many times as desired. 20

The printer described herein is also provided with an automatic blackness control circuit 215. This circuit comprises a one-shot multi-vibrator tachometer 308 whose output is delivered to an integrator circuit 310 whose output is amplified by a linear amplifier 312. The output of the amplifier 312 is delivered to the inputs of the amplifiers 314 in order to increase or decrease the voltage applied to the styli in accordance with the speed of the rotor. 25

The pulses delivered over line 284 have a frequency which is directly proportional to the rotor speed, since these are the fine pulses produced successively by the lines 166 in sensors A, B and C. The pulses at the output of the tachometer 308 have constant widths, since their widths are determined only by the characteristics of the multivibrator. However, since the time periods between the pulses varies with the speed of the rotor, the output of the integrator 310 varies in direct proportion to the rotor speed. This increases or decreases the output of the amplifier 312, and the amplifiers 314. As an example, in a preferred embodiment of the invention which has been built and successfully tested, the voltage applied to the styli was 50 at a printing speed of 500 characters per second. At 3,000 characters per second and the same number of lines and line spacing, the stylus voltage was 70 volts. 30

By means of the automatic blackness control circuit, the blackness and readability of the printed characters is maintained at a relatively constant level despite such wide variations in speed of the rotor. As a demonstration example highly satisfactory printing has been produced when the rotor is merely rotated by hand at a very low speed, as well as at speeds of up to 3,000 characters per second. 35

It should be understood that the speed of 3,000 characters per second is not believed to be the upper limit of speed for the device described herein. This speed will vary with the number of lines of characters being printed, etc. However, it is a significant advantage of the device described that a speed of up to 3,000 characters per second has been achieved in a relatively low cost, simple and compact machine. 40

It is envisaged that the printer described herein have wide utility in printing alphanumeric characters. For example, it is believed that it will be especially useful in producing "hard copy" from a cathode ray tube or television screen at a computer terminal or elsewhere. The "page" of data appearing at any one time on the cathode ray tube screen can be printed out as a unit rather easily. The printer described herein is so small (e.g. 4 inches by 4 inches by 8 inches or smaller) that it can be fitted into the same module with many cathode ray tube display screens. 45

The printer can be used advantageously in many applications where small size is important. For example, the printer is useful in aircraft, spacecraft, police, fire and other emergency vehicles. 50

It is believed that the printer described herein will make excellent low-cost, reliable stock quotation printer, especially when operated in the mode in which the printing is composed in a single line. 55

As one alternative embodiment of the invention, the logic circuitry of a computer terminal 60

can be used to replace some of the control circuitry shown in Figure 9. Alternatively, the printer control signals can be provided by specially programming a general purpose computer.

The number of print heads on the rotor can be varied, as can the number of styli in each head. However, the use of three print heads, with each printing one column of characters per pass, has been found to have decided advantages. It will be noted in Figure 3 that there is a slight variation from left to right of the starting point of the top and bottom lines of print. This is because, as the rotor is rotating, the recording paper is continuously moving, which means that the position at which the last line starts will be displaced longitudinally by a small amount from the place where the first line starts. It has been found, advantageously, that this slight amount of skew usually is not objectionable in data printers, and need not be compensated for. However, if it becomes objectionable in a particular use of the printer, the skew can be compensated in the manner shown in Figure 13.

Figure 13 is a schematic plan view of a printer like that shown in the previous figure of the drawings, except that the direction of paper feed is at an angle θ of 2 degrees and 4 minutes from the longitudinal axis of the printer, an angle which is sufficient to compensate for the skew produced by the printer. Of course, if variations in the number of heads and/or stylus wires are made, the compensation angle θ can be varied as necessary.

Although a mechanical system has been described for alignment of the printing by the three heads, one in which the adjustment is made by turning the cam wheels 158 and 160, the same adjustment can be made by purely electronic means. In this modification, the same function can be performed by the adjustment of counters which time the start of printing by each of the heads so as to cause the printing by the head to lead or lag the printing of the others by a certain amount. With present technology, however, it is believed that the mechanical adjustment described above gives good precision at a lower cost than it would require to obtain the same precession by electronic means.

Figure 14 shows a rotary printer 20 which is substantially the same as the printer shown in the previous Figures of the drawings, except for the rotor structure at the left end of the printer, and the paper grounding structure.

Referring now to Figures 14 and 15, three stylus heads 420 are pivotably mounted on the inside surface of the rotor 28. Only two heads 420 are shown in Figure 15, and only one of those heads is shown in Figure 14, in order to maintain the clarity of the drawings.

Referring now to Figures 17 and 18, as well as to Figures 14 and 15, each stylus head includes five closely-spaced parallel stylus wires 68 which are molded into a stylus support 424. Electrical energy is distributed to the styli by means of a printed circuit panel 426 which is secured to the support 424. This assembly is secured to an L-shaped slide member 428. Member 428 slides in a groove in a mounting block 422. An adjustment screw 432 is threadably engaged with the depending lower portion 430 of the slide 428, and is rotatably engaged with the body 422. Thus, by turning the screw 432 the slide 428 is moved and the position of the styli 68 on they body can be adjusted.

Each of the three stylus heads is pivotably mounted on the rotor 28 by means of a support structure which is shown in Figures 14 and 19 and will be described in greater detail below.

Each stylus head 420 has an arm 434 secured to the body 422 extending in a direction perpendicular to the direction of extent of the styli 68. At the end of the arm 434 is an enlarged hollow portion 436 which is filled with lead or contains a heavy metal insert 438. The insert 438 provides a relatively large mass for use in the centrifugal extension of the styli into engagement with the recording paper 36.

Referring now to Figure 15, attached to each arm 434 is a tension spring 454 whose other end is attached to a pin 456 which extends parallel to the drive shaft 48. The point of connection between the spring 457 and the arm 434 is between the block 422 and the end 436 of the arm 434.

The foregoing structure operates to automatically retract the styli 68 away from the recording paper 36 when the speed of rotation of the rotor 28 drops below a pre-determined minimum speed, e.g. 500 revolutions per minute or so. The tension springs rotate the print head 420 about their pivot axis, indicated at 452, in a clockwise direction. This moves the styli away from the paper 36.

When the rotor 28 starts rotating, centrifugal force acts on the heavy inserts 438 at the ends of the arms 434, applies tension to the springs, and rotates the arms 434 counter-clockwise. When the desired speed has been reached, the styli 68 engage the surface of the recording paper 36.

A stop structure is provided so that an increase in rotational speed does not cause the styli 68 to press too hard against the paper 36. This stop structure consists of a cam 458 (Figure 15) and a screw 460. The back edge of the body 422 of each print head engages the cam so as to stop the counter-clockwise rotation of the printhead due to centrifugal force and stabilize the positions of the styli 68 at the desired location. This location can be varied by turning the

screw 460.

The radial extent of the styli 68 can be adjusted, as it has been stated above, simply by turning the screw 432 in order to extend the styli radially outwardly or move them inwardly in order to adjust them, or in order to compensate for wear or dislocation of the initial positions of the styli.

Each of the stylus head 420 also can be adjusted axially (in a direction parallel to the drive shaft 48) by means of the structure shown in detail in Figure 19, and also in Figure 14. An adjustment screw 412 is provided with its head on the outer surface of the rotor disc 28. The screw has a smooth shaft 446 which fits into and slides within a sleeve 448 which acts as a bearing, both for the shaft 446, and also for the inner surface of the block 422. As it is shown in Figure 17, the block 422 is provided with a large hole 442 into which the sleeve 448 fits, and a small threaded hole 444 in a plate 440 (see Figure 18) attached to one side of the stylus head.

Referring again to Figure 19, the screw is held in place by means of a snap-ring 450 which fits into a groove in the end of the shaft 446. The shaft 446 has a threaded end 452 which fits into the threaded hole 444.

The adjustment of the head is made simply by inserting a screwdriver into the slot in the head 412 of the adjustment screw and turning it. This causes the distance between the block 422 and the disc 28 to change, thus providing axial alignment of each print head. This helps ensure that each of the characters in the printing produced by the printer will be properly spaced from the characters printed by each of the other stylus heads.

The rotor 28 is mounted on the shaft 48 by means of the structure shown in Figure 14. A hub 400 is provided. The rotor 28 is secured to the hub by means of four screws 402 (see Figure 16). Secured to the other end of the hub 400 is the slip-ring disc 104 which makes electrical contact with the electrical circuitry of the printer, in the manner described in greater detail above. A stop member 108 is provided on the shaft.

The hub 400 has a central recess in which the pins 456 are located. These are the pins to which the springs 454 are attached.

Still referring to Figure 14, the hub 400 has a recess 457 in its rear portion into which is inserted a compression spring 459. The compression spring bears against the stop member 108 and the hub 400 to thrust the rotor outwardly off of the shaft 48 and thus assist in removing it.

Referring now to Figure 16, the rotor 28 is secured to the end of the drive shaft 48 by means of a latch mechanism. The latch mechanism includes a latch member or plate 404 with two perpendicular end tabs 406 against which one can press in order to slide the member 404. The member 404 is secured to the outer surface of the rotor 28 by means of a pair of rivets 410 which bear against the slide 404 in a pair of elongated slots. Bowed washers (not shown) are positioned between the rivet heads and the slide in order to ensure a constant frictional engagement between the slide and the surface of the rotor, thus holding the slide in the position to which it is moved.

The slide 404 has a slot with an enlarged opening 408 whose diameter is slightly larger than the end of the drive shaft 48. The drive shaft 48 has a circumferential groove 418 (see Figure 14) into which the edges of the slide 406 in the slot fits in order to grip the end of the shaft 48.

Thus, simply by sliding the slide 406 downwardly, as shown in Figure 16, the slide will release its engagement with the end of the shaft so that the disc can be removed. Then, the spring 459 pushes outwardly on the rotor and assists in removing it.

When replacing the rotor 28, the end of the shaft 48 is inserted through the hole 408, and the slide 404 is pushed upwardly to re-engage the slide with the end of the shaft and secure the rotor in place.

The above-described rotor mounting and stylus adjusting structure is highly advantageous. Whenever it is desired to remove the rotor from the printer, or whenever it is desired to start a new strip of recording paper through the printer, the styli 68 will not interfere because they are retracted and out of engagement with the recording paper. Furthermore, the printer reaches proper printing speed more quickly because the friction of the styli against the paper is absent until the desired minimum operating speed has been reached.

The device provides means for axially adjusting the styli without removing the rotor from the printer. This adjustment can be made simply by turning the screws 412 which are exposed at the open left end of the printer.

A simple mechanical means also is provided for adjusting the effective length of the styli, simply by turning the screws 432. This makes it easy to initially align the styli for producing printing which is properly aligned and easy to read. Two of the three photocells and the related electronic circuitry used in the embodiment described above in Figures 1-13 for circumferential adjustment and timing of the operation of the styli can be eliminated because of the provision of mechanical adjustment by the use of screws 432.

The rotor is made very easy to remove by the provision of the simple slide latch shown in

Figure 16. The ease of removal is augmented by the use of the spring 459.

The movement of the styli towards and away from the recording paper can be accomplished by other than centrifugal means, if desired. For example, the styli can be extended by solenoids actuated a certain length of time after rotation of the styli has started. The same solenoids can be used to retract and hold the styli out of contact with the paper after the rotor has started decelerating or after it has come to a stop. The solenoids can be actuated manually, if desired.

Figure 14 also shows an alternative structure for grounding the recording paper 36. Instead of the curved spring structure 58 described above, the paper feed wheel 56 is made of metal (steel, e.g.), and is grounded by means of a brush 461. The brush 461 contacts the end of the axle 96 upon which wheel 56 is mounted. This structure provides an advantageous rolling ground contact to ground the recording paper. This eliminates the wear and friction caused by a sliding contact, and minimizes scratching of the paper. Furthermore, making the wheel 56 of metal instead of rubber prevents the wheel 56 from becoming indented due to its pressing against the wheel 98 when at rest for a substantial time.

Following are specifications for some of the materials and components of a printer which has been constructed and successfully tested in accordance with the present invention.

Suitable recording paper is readily available. Suitable papers, coated with a black opaque material and then coated with either aluminum or zinc oxide, have been obtained from Fitchberg C.P.I., Scranton, Pennsylvania, and from Atlan-Tol Industries. The preferred paper has a total thickness of 0.002 inch. The aluminum-coated paper is desirable because it often requires lower stylus voltages in order to vaporize the aluminum coating to expose the black material underneath.

Styli which have been used successfully have a diameter of 0.007 inch, and are spaced approximately 0.016 inch from one another, center-line to center-line. The desired spacing of the dots on the paper is approximately 0.016 inch, both in the horizontal and in the vertical direction. It should be noted, however, that sometimes there is a small vertical extension of the dots due to the rotation of the rotor. When printing characters, this sometimes improves the printing in that it tends to fuse the dots together into solid vertical lines.

The material of the styli is thoriated tungsten. The most desired range of angles between the styli and the platen is 60° to 70° (see Figure 6).

It is preferred that as much of the body of the printer as possible be molded out of plastic in order to achieve low cost and light weight. Thus, although the main drive shaft 48 is made of metal, the housing 24 and many other parts are molded out of reinforced plastic material such as glass fiber-filled polystyrene, which has good strength and wear properties.

The platen 26 preferably is molded out of glass fiber-filled "SAN" (styrene-acrylonitrile polymer), or out of glass fiber-filled "Lexan" (Registered Trade Mark) polycarbonate plastic material or nylon. A platen made of SAN and 30% short (e.g., less than 1/32" long) glass fiber has been found to have excellent characteristics, in that it is electrically non-conductive, and yet does not wear away significantly under the erosion of the styli, despite the fact that they are made of a very hard metal.

A.D.C. motor which has been found to be suitable for driving the printer is manufactured by Barber-Coleman Co., part number FYOM-63200-51. It has a diameter of 1.26 inches and a length of 1.95 inches. Its operating voltage is 12 volts D.C. and has a torque output of 1 ounce-inch at 4400 R.P.M. and 1.3 Amperes.

The optical sensors 146 used to sense the marks on the timing disc 54 are made by Optron Corporation. The sensor is called an "optical switch", part number OBP800. Also suitable is a similar device made by Spectronic, Part No. PNSPX 1872-s. The sensor has been modified simply by adding a mask as described above in the specification.

The code used to encode characters is the well-known code called "ASCII II". This is advantageous since code converters for use with such a code are readily available.

In the electrical control circuit of Figure 9, certain of the components will be identified specifically below. The components are readily available different sources unless it is indicated otherwise.

	<i>COMPONENT</i>	<i>IDENTIFICATION</i>	
	Rom Code Converter 202	2512 "Character Generator" Manufactured by Signetics Corp operates on ASCII II code	
5	Shift registers in Memory 200 and Shift Register 232	Integrated circuit shift register 2529, with data recirculation feature.	5
10	"Flip-Flops" 236,251,254,258, "Flip-Flops" 300, 302, 304 and 306	74LS integrated circuit D type (flip-flops) bi-stable multivibrators. 74LS73 J-K type integrated circuit (flip-flops) bi-stable multivibrators.	10
15	Multiplexer 282	Integrated circuit multiplexer type 74153.	15
20	Row counter 262	Integrated circuit 4 bit- counter connected as a divide by-16 circuit	20
	Margin space counter 246	74LS90 integrated circuit counter connected as a divide by-2 circuit.	
25	Line counter 278	74LS190 integrated circuit counter with 74LS74 flip-flop connected at the input as a divide -by-2 circuit.	25
	Gate 270	Number 7427 integrated circuit plus NOR gate.	
30	Integrator 310	A741 operational differential amplifier with capacity feed- back.	30
35	One-shot tachometer 308	An integrated circuit 74LS121 one-shot multivibrator	35
	AND gates 272	Integrated circuit No 7403 NAND gates	
40	Gates 222, 282, 294, 290	Integrated circuit 74LS08 AND gates	40
	Counter 288	Two 74LS193 integrated circuit counters connected as a divide- by 117 circuit	
45	OR Gates 218, 219 and 220	74LS02 integrated circuit NOR gates	45

WHAT WE CLAIM IS:

1. A rotary electrical graphic device including a substantially cylindrical platen, a rotor mounted to rotate within the platen cylinder, a plurality of stylic secured to said rotor, drive means for turning said rotor, record material feed means coupled to said drive means for feeding a strip of said material through said platen in contact with its inside surface with the stylic contacting said material at locations where the material is in contact with said platen and at a speed which is directly proportional to the speed of said rotor, and means for electrically energizing each of said styli.
2. A device as claimed in claim 1, in which said drive means includes a motor, a drive shaft driven by said motor and gear means for coupling said feed means to said shaft.
3. A device as claimed in either of claims 1 or 2, including a curved guide for guiding said strip towards said platen in arcuate form, said feed means including a feed roller for pushing said strip through said guide and said platen, said feed roller being located near said rotor at a point where said strip has said arcuate form.
4. A device as claimed in claim 3, in which said roller is electrically conductive, and including means for connecting said roller to electrical ground.
5. A device as claimed in any of claims 1 to 4, in which said drive means comprises a direct current motor.

6. A device as claimed in any of claims 1 to 5, in which said platen is made of electrically insulating material and forms a platen surface on its inside wall, a cylindrical housing for said drive means, said housing and said platen being joined together end-to-end, with the outside of said housing being spaced radially inwardly from said inside surface of said platen.

5 7. A device as claimed in claim 6, in which the material of which said platen is made is a glass fibre-filled plastics material. 5

8. A device as claimed in claim 6, said drive means including a shaft extending axially in said housing for rotatably supporting said rotor, a motor coupled to rotate said shaft, said feed roller being mounted in said housing with one edge adjacent the outside of said housing, drive 10 coupling means for drivably coupling said feed roller to said shaft, said curved guide being located opposite said roller for guiding said strip across the outside of said housing in arcuate form. 10

9. A device as claimed in claim 8, including means for releasably attaching said curved guide means to the exterior of said housing, and in which said guide means has an idler roller 15 positioned to meet with said feed roller when said guide means is in operative position. 15

10. A device as claimed in claim 9, in which said attaching means includes a hinge at one edge and a latch at the other, and including two guide members at the edges of said curved guide means for edge-guiding a strip of paper axially of said housing between the exterior of said housing and said guide means.

20 11. A device as claimed in any one of claims 1 to 10, in which each of said styli comprises an elongated conductor forming an angle of substantially less than 45 degrees with said guide at the point of contact between said stylus and said record material. 20

12. A device as claimed in claim 11, in which said angle is approximately 30 degrees.

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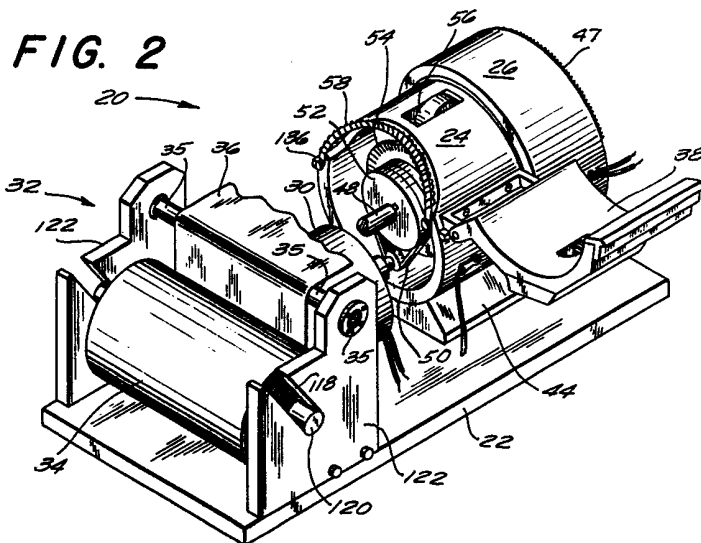
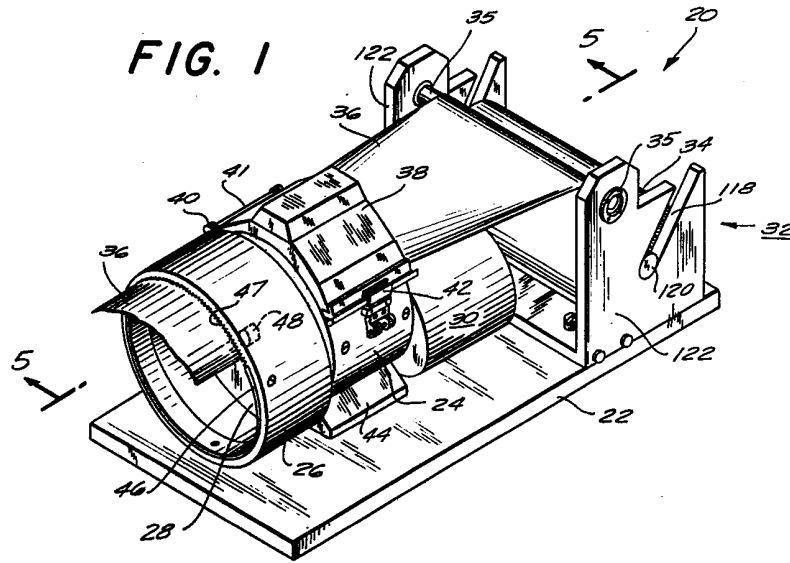


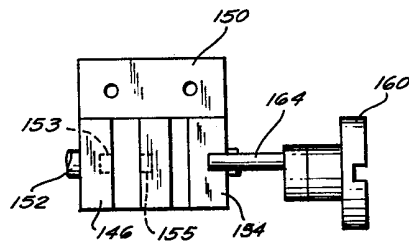
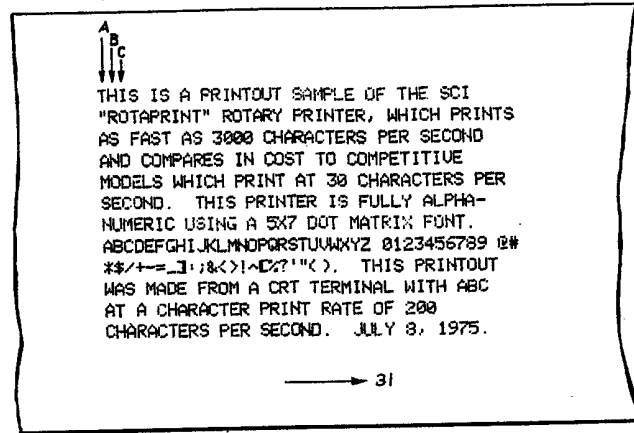
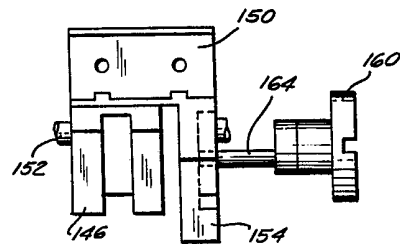
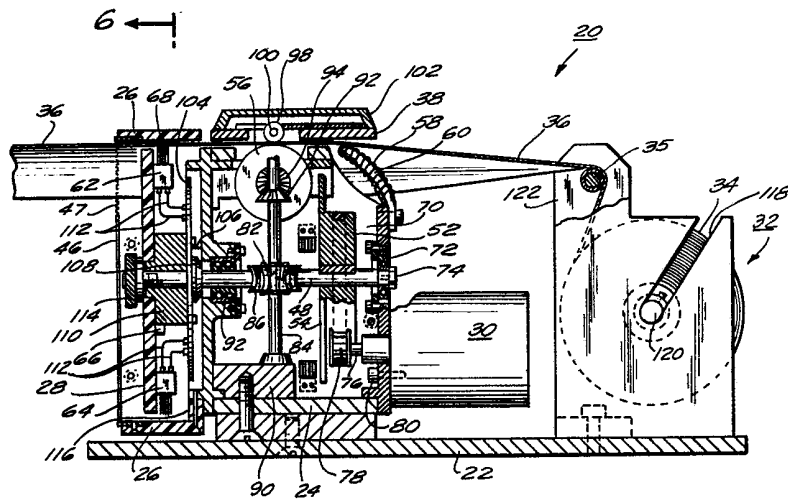
FIG. 3**FIG. 11****FIG. 12**



FIG. 5



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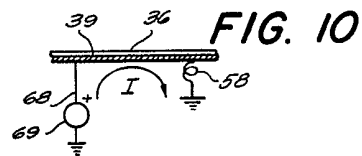


FIG. 10

FIG. 13

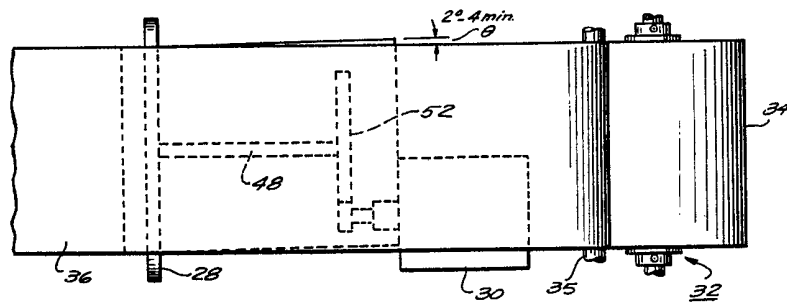


FIG. 6

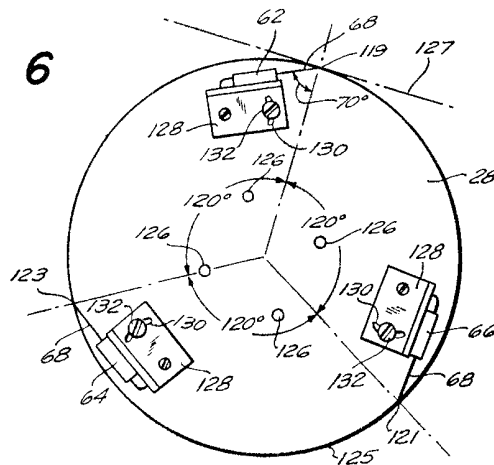


FIG. 7

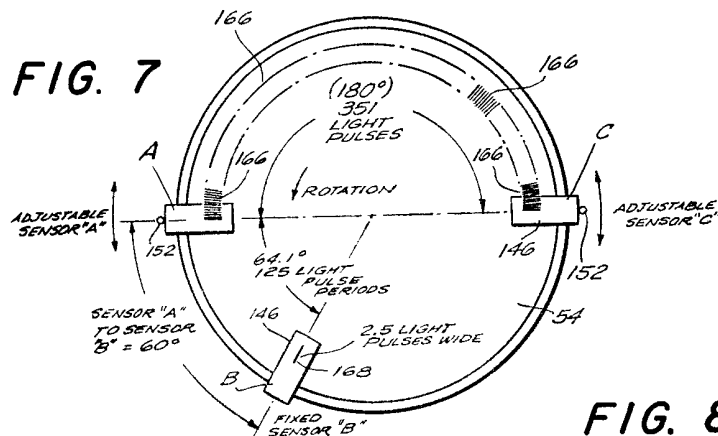
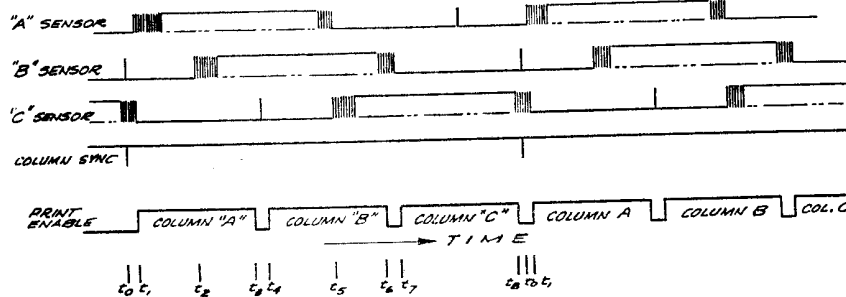
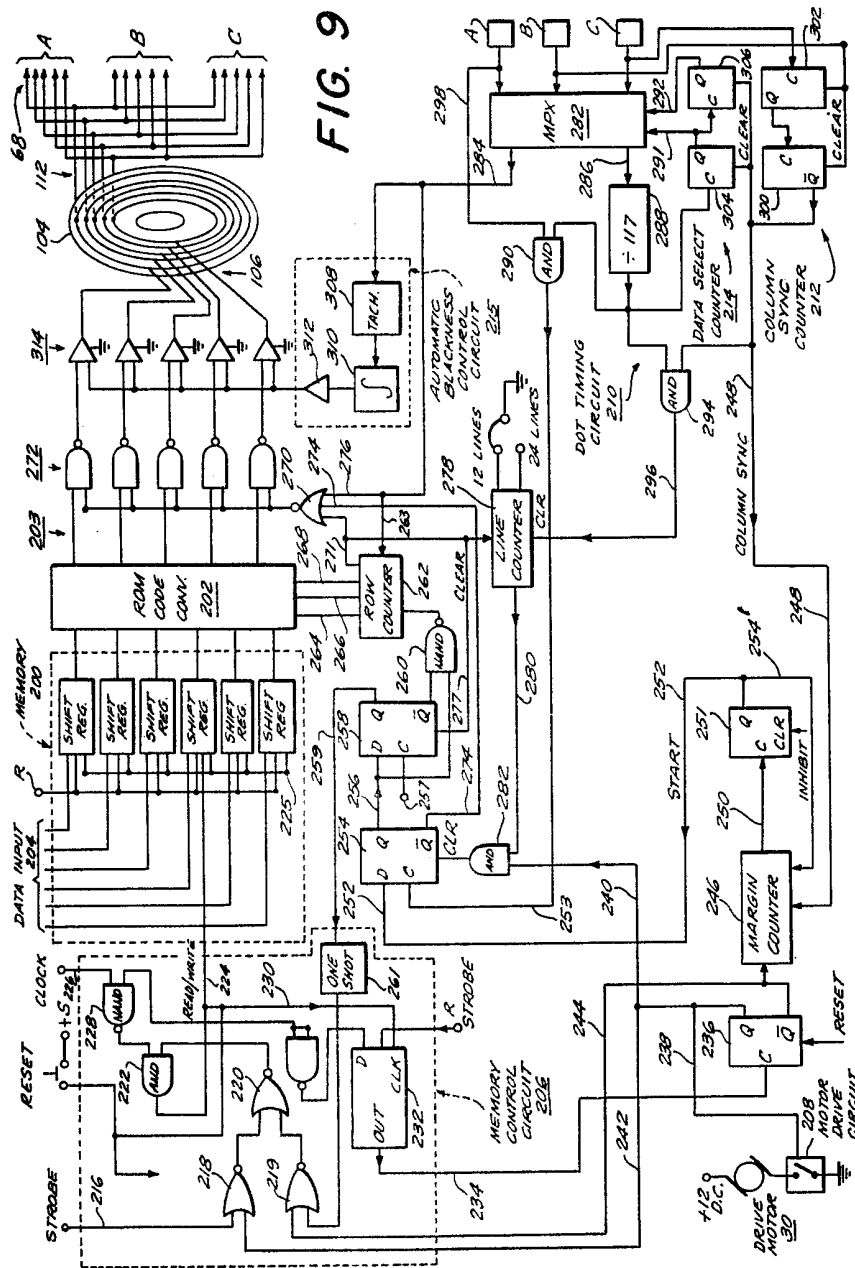


FIG. 8





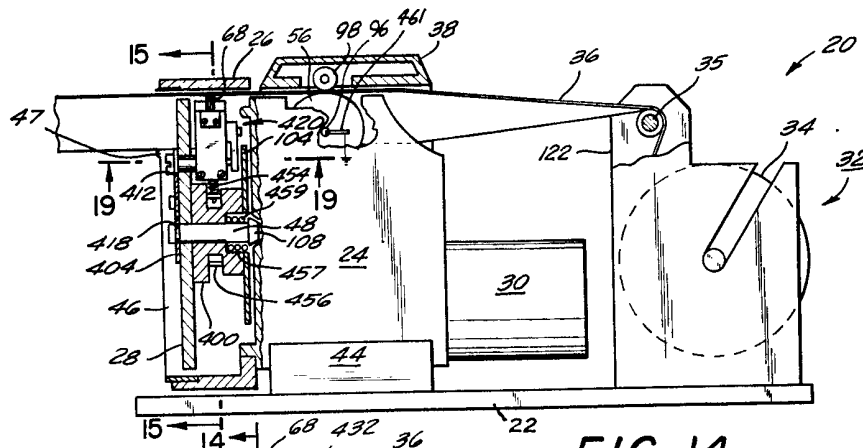


FIG. 14

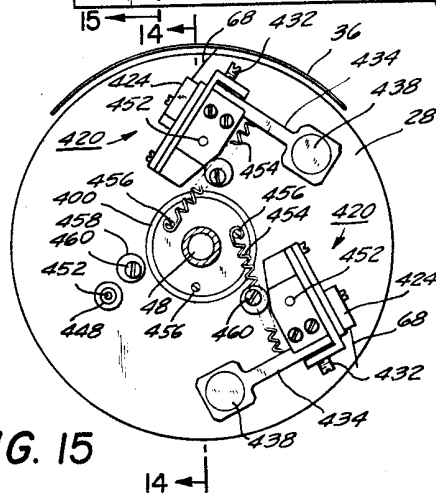


FIG. 15

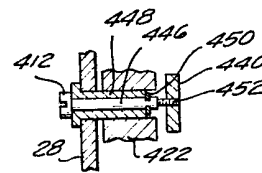


FIG. 19

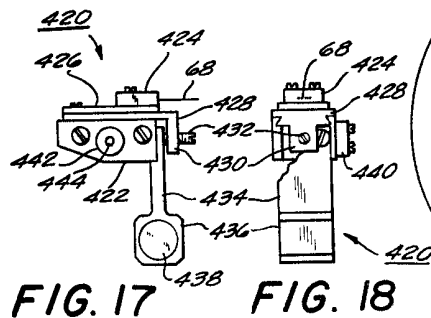


FIG. 17

FIG. 18

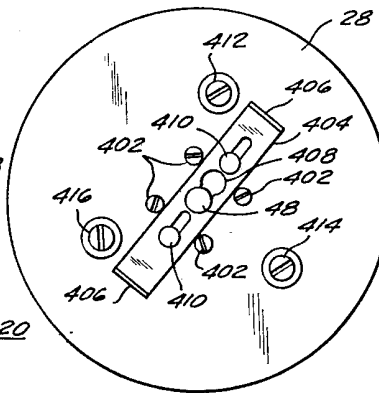


FIG. 16