Nov. 2, 1965 R. E. ABERNATHY ETAL 3,215,070

PRINTER SYSTEM WITH CONTINUOUSLY ROTATING PRINT WHEELS

Filed Dec. 17, 1963 2 Sheets-Sheet 1

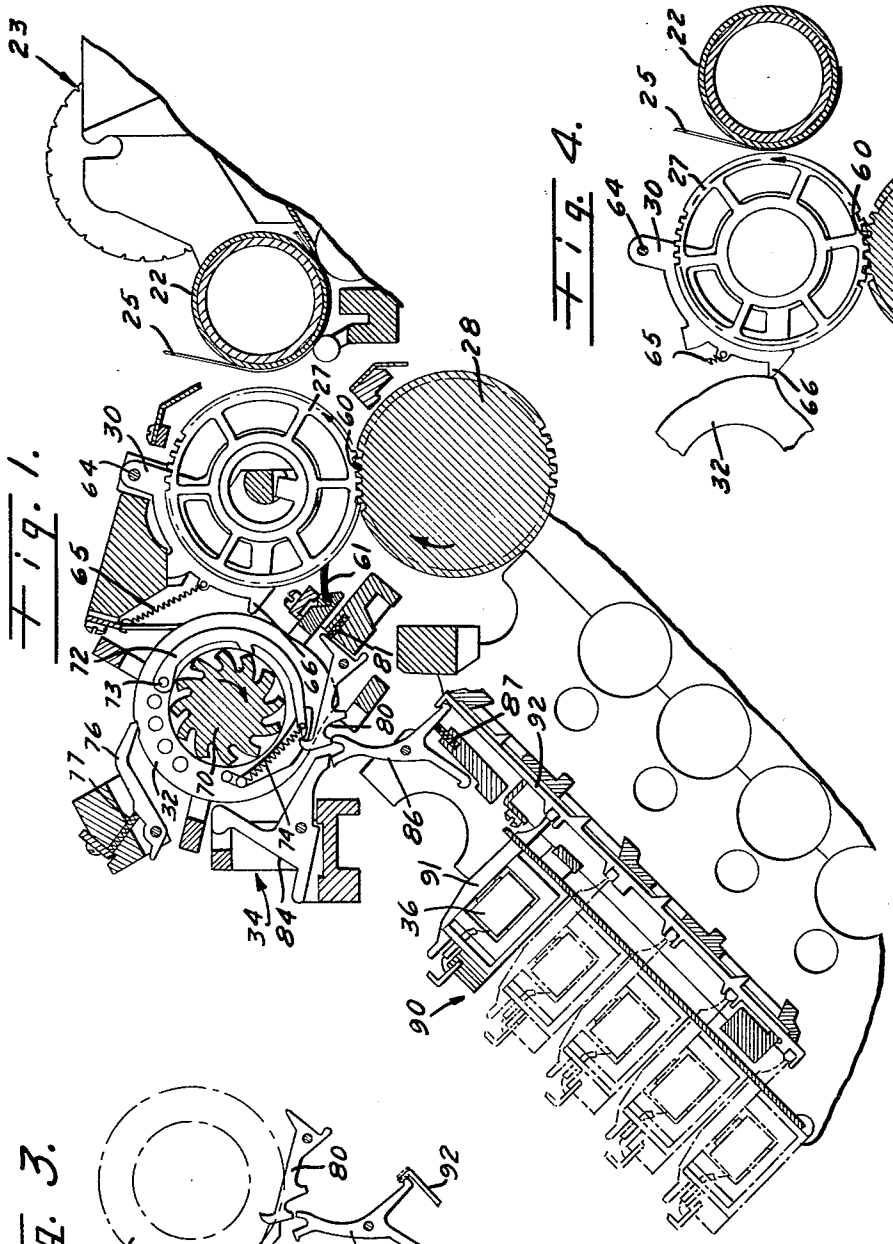

Fig. 1.

Fig. 4.

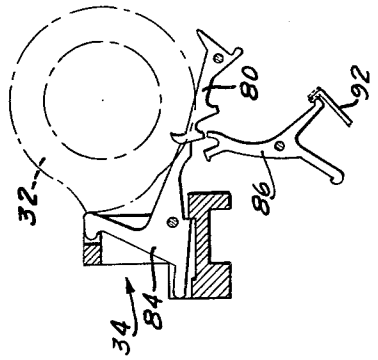

Fig. 3.

INVENTORS.
Roger E. Abernathy
Leonard R. Harper
by Fraser and Bogucki
Attorneys

Nov. 2, 1965 R. E. ABERNATHY ETAL 3,215,070

PRINTER SYSTEM WITH CONTINUOUSLY ROTATING PRINT WHEELS

Filed Dec. 17, 1963 2 Sheets-Sheet 2

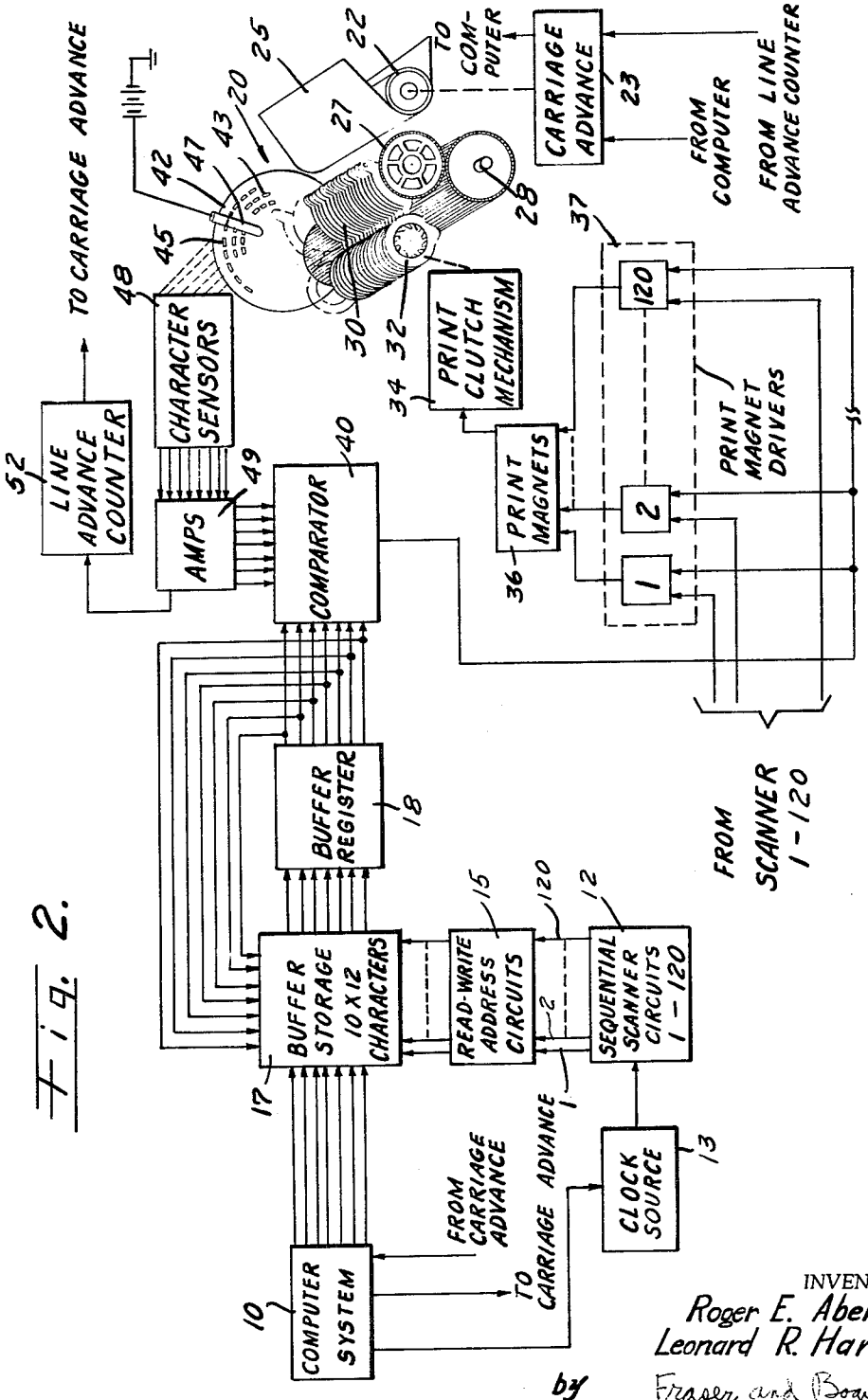

Fig. 2.

INVENTORS.
Roger E. Abernathy
Leonard R. Harper
by Fraser and Bogucki
Attorneys

United States Patent Office

3,215,070

Patented Nov. 2, 1965

3,215,070

PRINTER SYSTEM WITH CONTINUOUSLY ROTATING PRINT WHEELS

Roger E. Abernathy, Boeblingen, Germany, and Leonard R. Harper, San Jose, Calif., assignors to International Business Machines Corporation, New York, N.Y., a corporation of New York

Filed Dec. 17, 1963, Ser. No. 331,199

9 Claims. (Cl. 101—95)

This invention relates to printing mechanisms and more particularly to printers which print a line at a time in response to data generated in the standard format of an electronic data processing machine.

A number of different high speed printing mechanisms have been developed in order to record the data generated by an electronic data processing system at a rate somewhat compatible with the computing speed of the data processing system. Many of these printers use a "line-at-a-time" principle, and employ a rotating type wheel drum having a separate type wheel for each printing position along a line. Usually, a print hammer and an actuating mechanism are disposed behind the paper, and the hammers at each printing position are impulsed against the paper, at appropriate times in the print wheel cycle. With such a system an electronic data storage is ordinarily employed to supply control impulses for each column in timed relationship to the drum rotation. Thus, each printing hammer is actuated when the proper character on the associated type wheel is at the printing position.

The data which is provided from a data processing system for this purpose is generated in a standard format, usually suitable for entry in a magnetic tape transport. The data may be read from the tape transport system, or provided directly to the printer control system from the data processing system. Line-at-a-time printers of this type may have 80 to 100 printing positions per line, and may advance the paper and print at extremely high speeds, such as 600 lines per minute.

In order to achieve very high speeds, the hammers of a printer must be actuated "on the fly," while in order to achieve the necessary clarity and reliability they must be quite complex and expensive. Special paper advance and tensioning mechanisms must also be used to hold the paper taut, so that such printers are usually extremely noisy in operation. In this type of high speed mechanism, which is often referred to as a "back printer" because of the position of the actuating hammer relative to the paper, the paper and ribbon must be fed into the center of the printing mechanism, so that loading and feeding often become quite difficult. Separation of the printer mechanism into two separate parts in this manner also increases the cost of such systems. Whether or not the print wheel is continuously rotating during the printing operation, the impingement of the hammer against the back of the paper results in some loss of clarity in the printed characters, and sometimes introduces severe smearing effects.

For many applications it is unnecessary to achieve the high line speeds which can be obtained with some of the modern line-at-a-time printers. Many different front printer mechanisms are known, for example, which operate at relatively high speeds, such as 50 to 150 lines per minute. A printer of this type has been sold for many years as the Type 407 accounting machine by the International Business Machines Corporation of New York, New York. The mechanism and operation of such a printer are described, for example, in the patent to Page et al. entitled, Perforated Card Controlled Alphabet and Numeral Printer, Patent No. 2,438,071, March 16, 1948. As described in that patent and as is known to those skilled in the art, the Type 407 printer is a front printer using a rotatable type wheel for each of 120 printing positions,

and operating at the rate of 150 operations per minute. Under control of a print magnet assembly, a selector clutch gear and a print cam cooperate with the printer type wheel to rotate the type wheel to present a selected character face at the print position, and to urge the type wheel against the platen and the paper. There is substantially no relative rotational movement between the type wheel and the paper at the time of printing.

Stated in a very general way, the operation of this type of print mechanism utilizes the selector clutch mechanism to select one of twelve segments about the type wheel, while the print cam is utilized to select one of four printing times. An analyzer system controlled by punched card data is utilized for generating appropriate signals for controlling the selector clutch gear and the print cam. As is well known to those skilled in the art, the most widely used punched card codes employ two fields, one having print positions for values 1 through 9 and the other four different positions which may be referred to as 0, 11, 12 and N positions. The selector clutch mechanism is controlled by impulses for values 1 through 9, while the 0, 11, 12 and N impulses control the print cam. The 48 different printing positions are selected by using different combinations of zones as well as the individual printing or punching positions within the zones. These relationships are well understood and need not further be described here in detail.

Nevertheless, it is apparent that with the selector clutch mechanism and the print cam mechanism operating with such a degree of dependence upon a particular punched card analyzer mechanism, it is not convenient to operate printers such as the Type 407 from a standard data format prepared by an electronic data processing machine. In contrast to the 80 or 120 columns of a punched card, each of which columns controls the printing of a separate character within a given line, the characters provided by a data processing system are usually in the form of parallel binary diget codes of six, seven or eight digits. Each character is serially displaced along a tape, or serially provided in time, although the characters may be grouped into separate blocks, each of which includes a line of data for the printer. Direct use of such data to control a printer such as the Type 407 accounting machine would require that the serially disposed or provided data be converted into a form equivalent to the punched card code, for operating the analyzer mechanism and the print magnet assemblies of the Type 407 printer.

Obviously, it is desirable to use the advantageous features of the Type 407 printer, including existing and proven parts of the mechanism, and to obtain the greater clarity which is achieved by front printing. If elements of the same basic mechanism can be employed in conjunction with a control system to print directly from a computer format without the necessity for extensive conversion equipment, many advantages of cost and reliability can be obtained. If the system organization and printer design further improve the mechanism by reduction of cost and by elimination of complex operative parts, a novel system having unique reliability characteristics will have been achieved.

It is therefore an object of the present invention to provide an improved printing mechanism and system for electronic data processing machines.

Another object of the present invention is to provide an improved type of front operated, line-at-a-time, printer for use with data provided in the standard format of electronic data processing systems.

Another object of the present invention is to provide an improved front printer utilizing at least portions of a rotary wheel printing mechanism of a type formerly utilized with punched card input date, and operating with data provided from electronic data processing machines.

These and other objects are achieved in accordance with the invention by line printer mechanisms which are completely front mounted in relation to a platen. For each column along a printing line, a type wheel is continuously rotated in a selected direction. At desired print times for each of the type wheels, a print cam is actuated such as to rotate the type wheel against the printing position, in a manner which momentarily cancels rotational movement of the type wheel during engagement at the printing position. The print cams are relatched during the same rotation and a new printing cycle may be begun after a partial cycle delay.

In a specific example of a system in accordance with the invention, the type wheels at each of a number of printing positions are continuously rotated by a drive gear. The print cam assembly at each of the positions may be operated at any one of forty-eight different print times (one for each of the forty-eight possible print characters). To effect actuation of the print cams, the characters to be printed are entered into a buffer storage, from which they are successively presented for comparison and re-entered in high speed cycles as each of the print characters on the type wheels passes the printing position. A code wheel system which generates character signal patterns is driven by a mechanical synchronizing system which is coupled to the type wheel mechanisms. The characters presented by the code wheel serve as references for the comparisons which control actuation of the print magnet assembly and energization of appropriate print cams.

An important aspect of the invention pertains to the mechanisms by which the type wheels are actuated by time-distributed impulses within a single cycle, and by which the clutching mechanism is automatically relatched. The print cam which impulses the type wheel is engaged to a print clutch reamer by a print clutch dog which is automatically disengaged after a full print cam cycle. To this end, the cam lobe on the print cam, which effects printing, also operates a clutch relatch member which in turn returns a clutch latch to its original position, in which the print clutch dog is disengaged. Although a full cycle of the print clutch reamer is used for relatch, only a fraction of the type wheel cycle is involved.

A feature of the invention is the use of a print clutch reamer shaft cycling arrangement which permits a delay sufficient to latch up clutches operated on the previous reamer shaft cycle. The type wheel revolution requires less time than a complete print cycle because of this delay, and the excess fraction of each print cycle is devoted to the latchup interval. Accordingly, the type wheel character which starts each successive print cycle changes with each rotation of the type wheel. The data characters are, however, continually referenced to the actual characters presented at the type wheels, so that synchronism and character referencing are maintained.

Another feature of the present invention is the use of a spirally cut print clutch reamer shaft which distributes type wheel impacts, for the same type character, over a period of time. This "ripple" time, in conjunction with the use of 48 different print times within a cycle, materially reduces the paper feed mechanism which is required and further operates in a complementary fashion to the scanning of the various printing positions in the data buffer.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

FIG. 1 is a side view, partially in section, of the principal elements of a printing mechanism in accordance with the invention;

FIG. 2 is a block diagram of the principal elements of a line printer in accordance with the invention;

FIG. 3 is a side sectional view of a portion of the arrangement of FIG. 1 showing the position of the operating members at one point during the operation; and

FIG. 4 is a side sectional view of a portion of the arrangement of FIG. 1 showing the position of the operating members at a second point during the operation.

The printing mechanism shown in detail in FIGS. 1 and 3 operates in cooperation with a unique control system to provide an integrated overall operation having distinct advantages over the prior art. Appreciation of this system organization, as described immediately below in conjunction with FIG. 2, will enable more ready understanding of the arrangement and mechanical operation of the mechanism of FIGS. 1, 3 and 4.

Data for the printer is provided from a computer system **10** in a parallel by digit and serial by character format, such as six parallel binary digits plus a parity digit. For actuation of a line-at-a-time printer, the programming of the computer system **10** will ordinarily be undertaken so as to provide data blocks of 120 characters each, followed if desired by special signals to control special advances of the carriage mechnism of the printer. The computer system **10** may operate through an input/output buffer system (not shown) which returns desired response signals to the computer so that data transfer may be continued on an orderly basis. All such arrangements are well known to those skilled in the art and accordingly are not described in detail herein. Similarly, it will be appreciated that where the printer mechanism is not to be operated on-line with the computer system, the data from the computer may be entered into a tape station in block or other form, for subsequent control of the printer. Inasmuch as details of this nature are not of concern to the operation or arrangement of the present invention, they have been omitted and the system description assumes that the computer system provides data in blocks of 120 characters, to be disposed along the columns of a printing line, which blocks are followed by carriage advance signals for control of the printer when the paper is to be advanced by more than one line.

The control system is loaded with the characters representing each line of printing commands whenever the last previous group of characters has been printed out, as indicated by a signal such as is generated to control carriage advance. During the load interval, the computer system **10** provides a control signal to a sequential scanner circuit **12** which also receives clock pulses from a clock pulse source **13**. Although the clock pulses may be derived from the internal clock of the computer system, the clock source **13** is here shown separately in order to represent more clearly that it operates the sequential scanner circuits **12** in a repetitive fashion as data is transferred in at the transfer rate of the computer system **10** during the load cycle. The scanner circuits **12** operate in conjunction with read write address circuits **15** which control the entry of data into a 120 character buffer storage **17** which may, for example, be a core memory arranged in a 10 x 12 matrix and having seven cores per character position. Inasmuch as the operation of the buffer storage **17** is repetitive, a random access function need not be provided and the combination of scanner circuits **12** and read-write address circuits **15** may assume any of a number of different relatively simple forms. With a 10 x 12 matrix, for example, the circuits may take the form of driver circuits for the X and Y coordinates which are controlled by X and Y address counters through appropriate conversion matrices, the counters being stepped so that during the writing of data the characters are entered in the successive row positions of first one column, then another and so on.

During the read operation, again conducted under control of the clock, the addressing circuits may be controlled in a similar fashion, with the common read windings for each plane of the core memory being coupled to provide the binary digits in parallel to a buffer register **18**, such as a group of parallel flip-flops. The memory system is utilized in a recirculating fashion, to rewrite the character which is read from a storage position back into the buffer storage **17** substantially immediately, before proceeding

to readout of the next character in the sequence. This recirculation is carried out at a rate compatible with the clock rate of the computer system **10**, such as, for example, 47,400 characters per second. As will be described in more detail below, there is more than adequate time during printer operation for completing the loading cycle for the buffer storage **17**, and for scanning each position in the buffer storage **17**, as well as recirculating the data back into the storage **17** for each successive printing position of the typing mechanism.

A group of characters corresponding to a given line to be printed is entered during a load interval into the storage **17**. The characters are then made available repeatedly at a very high rate of speed at the buffer register **18** as the printer mechanism **20** is concurrently operating at a much slower rate of speed. The printer mechanism **20** may utilize a conventional platen **22** and carriage advance **23**, such as are employed in the Type 407 printer. For each of 120 columns or printing positions across a paper **25** which is moved by the carriage advance mechanism **23**, the printer includes a separate type wheel **27** which is continuously rotated by a cylindrical drive wheel **28**. Each type wheel **27** is suspended in a wheel hanger **30** which permits the type wheel **27** to be urged toward the platen **22** while still remaining in engagement with the drive wheel **28**. A print cam **32** positioned adjacent the wheel hanger **30** at each printing position may be actuated so as to rotate a raised cam lobe toward the printing position, urging the wheel hanger **30** and the type wheel **27** toward the printing position. The operation of this mechanism imparts a rotational movement to the type wheel **27** which is opposite to that imparted by the drive wheel **28**, and the type wheel **27** is thereby impressed against the paper **25** and the platen **22** with substantially no relative rotational movement but with adequate force for imprinting a character. For each print clutch mechanism **34** a separate magnet **36** operated by a print magnet driver **37** is employed.

The various print magnet drivers **37** are scanned under control of the scanner circuits **12** in synchronism with the scanning of the positions of the buffer storage **17**. Print signals are initiated for each column, whenever a desired print character is presented on the face of the type wheel during a type wheel revolution.

This determination of "time to print" for a given continuously rotating type wheel **27** is made by a comparator **40** which receives binary coded characters from the buffer register **18** and which also receives binary coded characters indicative of the character then presented by the type wheels **27** at the printing position. To this end, a code wheel **42** is mechanically coupled to the continuously rotating drive wheel **28**. The type wheels **27** are provided with forty-eight peripheral characters (twenty-six alphabetic characters, ten numbers and twelve special characters), and the code wheel **42** similarly contains forty-eight radially symmetrical binary patterns **43**, as well as an outer radius clock track **45**. The code wheel **42** is preferably a solid disc having perforations corresponding to the binary code patterns, although a reference member of varying reflectivity or vary opacity may also be utilized. With the perforated disc configuration, however, a single light **47** can be utilized on one side of the disc **42**, and a number of individual character sensors **48** may be disposed adjacent the different radial patterns on the disc **42**. Therefore, rotation of the index wheel **42** causes generation at the character sensors **48** of successive binary signal combinations which represent the successive individual characters which are presented opposite the printing position on the platen **22**. With a type wheel rotation of 100 revolutions per minute, these conditions will be seen to result in the generation of eight characters per second, the signals being provided through parallel amplifiers **49** to the comparator **40**. Concurrently, a signal representing the clock track on the code wheel **42** is provided to a line advance counter **52** which counts a desired number of pulses and applies a trigger pulse to the carriage advance mechanism **23**. Output pulses are provided at both the count of 48, corresponding to the total number of characters on the type wheel, and a count of 60, the additional 12 counts after a complete revolution of the type wheel being utilized to provide a delay time for permitting release and latch up of the various clutch mechanisms, and also for paper advance. In addition, this delay interval may be utilized for reloading the buffer storage **17**.

It will be appreciated by those skilled in the art that this arrangement provides an extremely simple means of coordinating the operation of the computer system **10** which provides data in a standard format with a continuously operating but relatively slow front printer system. A delay interval is provided during which each of the necessary mechanical resetting or readjustment operations may be undertaken. This delay interval, however, does not require that the system be re-indexed to a starting point. Many present day systems utilize counter arrangements for specifying successive index points in a cycle. Such systems then may generate the command for printing at a given column in the form of a count which is successively decreased until a zero count is reached, at which time the printing command is generated. Instead, because an actual reference to the character itself is provided from the code wheel **42**, the printing cycle can be begun at any time, and no indexing point on the type wheel or reset cycle need be used. By comparing the actual characters which are presented at the printing position in this manner, the printing commands which are entered in the buffer storage are converted to command control signals which occur at different times within intermittently generated printing cycles.

The arrangement and operation of the electro-mechanical and mechanical elements of a printer mechanism in accordance with the invention are best seen in detail in FIGS. 1, 3 and 4, in which the same reference numerals are employed as in FIG. 2. The paper **25** is advanced on the platen in the paper carriage advance mechanism **23**. The elements of the paper advance mechanism are shown only in partial detail or have been omitted, inasmuch as any conventional structure may be used, including the Type 407 printer carriage. Similarly, the frame, unit mountings and other associated structure, have been omitted for clarity.

The type wheel **27** has **48** symmetrically disposed type faces **60**, the sides of the type faces **60** being so configured that they also form gear teeth about the periphery of the type wheel **27**. The type wheel **27** is normally rotated at 100 r.p.m. in a counterclockwise direction, as viewed in FIGS. 1, 3 and 4, although the axis of rotation of the type wheel **27** may be shifted as described below. As the type wheel rotates while out of contact with the paper **25** and the platen **22**, it is continuously cleaned by a type wheel brush **61**.

The type wheel **27** is rotatably supported in a type wheel hanger **30** which is supported in a pivot mount **64** in the frame of the printer mechanism. The type wheel hanger **30** therefore permits movement of the type wheel **27** in a direction toward or away from the platen **22**, the type wheel normally being held in the position furthest from the platen **22** by a biasing spring **65** which couples the type wheel and hanger **30** to a part of the frame. A cam follower surface **66** extends from the type wheel hanger **30** in the direction of the associated print cam, and rides in contact with the cam surface under the action of the biasing spring **65**. For rotational movement of the type wheel **27**, a continuously rotating type wheel drive gear **28** is utilized which turns clockwise (as viewed in FIGS. 1, 3 and 4) and which has gear teeth mating with the teeth formed in the periphery of each type wheel **27**. Although it will be recognized that there are separate type wheels **27** and associated cams for each of the 120 printing columns of the printer, there is

only one platen 22 and one type wheel drive gear 28 for the entire assembly.

A print cam 32 for each printing position is mounted about a single print clutch reamer 70 which rotates continuously in the clockwise direction (as viewed in FIG. 1). The print clutch reamer 70 has 12 surface teeth which are engaged by the print clutch mechanism 34 which operates the print cam 32 in response to actuating signals. The rate of rotation of the print clutch reamer 70 is 400 r.p.m., so that the ratio of the speed of the print clutch reamer 70 to that of the wheels 27 is the same as the ratio of the number of type wheel teeth to reamer teeth. An associated print clutch dog 72 includes an engaging dog member which is normally held out of contact with the teeth of the print clutch reamer 70. At one end the print clutch dog 72 is supported in a pivot mount 73 on the print cam 32, and at the other, or free end, it is urged toward engagement with the print clutch reamer 70 by a spring 74 coupling it to the print cam 32. When not engaged with the print clutch reamer 70 through the print clutch dog 72, a detent notch in the print cam 32 engages a print cam detent 76. A spring 77 continually maintains the print cam detent 76 in contact with the print cam 32. The print cam 32, when at rest, is thus restrained from movement in either rotational direction on the reamer 70.

The print clutch dog 72 is normally maintained out of engagement with the print clutch reamer 70 by a print clutch latch 80 which is biased towards disengagement from the print clutch dog 72 by a spring 81. A clutch relatch lever 84 and a magnet armature knock-off lever 86 cooperate with the print clutch latch 80 to control operation of the print clutch dog 72. The clutch relatch lever 84 is pivotally mounted, and includes one extended arm which rides on the cam surface of the print cam 32, and another arm which is aligned with the print clutch latch 80. The magnet armature knock-off lever 86 is also pivotally mounted, and includes an arm which blocks the print clutch latch 80, when the lever 86 is in a first position, to prevent the print clutch latch 80 from disengaging from the print clutch dog 72 until an actuating signal is applied. The magnet armature knock-off lever 86 is maintained in its first position by a resilient bumper 87, and shifted out of this position by the operation of the print magnet assembly 90. For each column position along the platen 22, there is a single print magnet armature 91 controlled by the associated print magnet 36. The print magnet armature is pivotally mounted to engage and withdraw a print link 92 which acts against the magnet armature knock-off lever 86. Note in FIG. 1 that the various print magnets 36 which are shown are disposed at successive positions. Only one print magnet 36 is utilized to control a given print link 92 and the associated clutching mechanism for generation of the printing action.

It should be observed that the character faces may be disposed on the type wheel 27 in any sequence, so that existing type wheels may be utilized even though they are specially prepared for use with punched card codes or for other purposes. The type wheels 27 must of course have like character sequences, but apart from this requirement all that need be done is to utilize a code wheel 42 having a similar character sequence. Note also that the character patterns on the code wheel 42 (FIG. 2) should be displaced from those on the type wheel 27 by an amount determined by the angular displacement between the position of the type wheel 27 at the time of application of the energizing signal for a given print position, and the subsequent position of the same point on the periphery of the type wheel 27 when it is urged against the platen 22. This angular displacement is determined by the time required for the print clutch dog 72 to be actuated to rotate the print cam 32 with the print clutch reamer 70, moving the cam lobe on the print cam 32 into engagement with the cam follower 66 on the type wheel hanger 30. Although this is about 270° of rotation for the print cam, the rate of rotation of the print clutch reamer 70 is four times as fast as that of the type wheel 27, so that only about 70° of the rotation of the type wheel 27 are required.

The print clutch reamer 70 teeth are not disposed along axes which are parallel to the longitudinal axis of the print clutch reamer 70, but instead form spirals having an angle of approximately 7° angle relative to the longitudinal axis of the reamer 70 shaft. The sense of the angle of the spiral is determined by the direction in which the various column positions are scanned, as well as by the direction of rotation of the print clutch reamer 70. The leading edge of the spiral is placed at the end of which the first column position is scanned by the control circuits, so that the same gear tooth on the print clutch reamer 70 is presented successively later in time at the successive column positions.

Operation of the print mechanism in a given column print position, referring still to FIGS. 1, 3 and 4, takes place under control of the print magnet 36. Prior to printing (FIG. 1), the type wheel 27 is maintained out of contact with the paper 25 and the platen 22, as the type wheel hanger 30 is held by the biasing spring 65. The type wheel is continuously rotated counterclockwise at 100 r.p.m. by the type wheel drive gear 28, the gear teeth of the drive gear 28 remaining in contact with those of the type wheel 27 at all times. The print cam 32 is held stationary about the print clutch reamer 70 as it rotates at 400 r.p.m., the print cam 32 being positively held in its index position by the print cam detent 76 and the print clutch latch 80 which act in opposite directions against the detent notch and the free end of the print clutch dog 72 respectively. The magnet armature knock-off lever 86 is in what may be referred to as its first position, with an arm blocking the print clutch latch 80 to prevent the print clutch latch from releasing the print clutch dog 72. This first position is stably maintained because of the resilient bumper 87 which urges a second arm of the magnet armature knock-off lever 86 into contact with the print link 92 which is controlled by the print magnet assembly 90.

At a given time in the print cycle, when it is determined that the character presented by the code wheel corresponds to the character stored for a column position in the buffer storage, an energizing signal is applied to the print magnet 36 for that position. Energization of the print magnet 36 pivots the print magnet armature 91 and longitudinally moves the print link 92 so as to tend to rotate the magnet armature knock-off lever 86 clockwise against the resilient bumper 87. The magnet armature knock-off lever 86 moves to its second position, in which the surface presented to block the print clutch latch 80 from movement is moved laterally, and the print clutch latch 80 is thereby urged by its biasing spring 81 out of contact with the free end of the print clutch dog 72.

The print clutch dog 72, being free to pivot, is drawn inwardly relative to the print clutch reamer 70 by the spring 74, causing the engaging dog to engage an appropriate gear tooth in the print clutch reamer 70, so that the print cam 32 immediately begins to rotate clockwise with the print clutch reamer 70 at 400 r.p.m. As the print cam 32 starts to rotate with the print clutch reamer 70, the print cam detent 76 automatically slides out of the detent notch.

Printing is completed within one print clutch reamer 70 cycle after the cam lobes of the print cam 32 acts aganist the cam follower 66 on the type wheel hanger 30. The relatch operation for the various elements of the print clutch mechanism is undertaken substantially immediately under control of the cam lobe of the print cam 32. The clutch relatch lever 84 rides against the cam surface, and when the cam lobe is encountered, the clutch relatch lever 84 is turned counterclockwise, rotating an

extended arm into contact with the print clutch latch 80, as shown in the fragmentary view of FIG. 3. The print clutch latch 80 is turned into the path of the print clutch dog 72, permitting the magnet armature knock-off lever 86 to be urged by its resilient bumper 87 back into its first position, in which it holds the print clutch latch 80 in the path of the free end of the print clutch dog 72.

Printing subsequently takes place as the print cam lobe continues to rotate clockwise toward the cam follower 66 on the type wheel hanger 30. As the high point of the cam lobe approaches the cam follower 66, the type wheel hanger 30 and the type wheel 27 are given a sudden acceleration toward the paper 25 and the platen 22, as shown specifically in FIG. 4. Thus the type wheel 27 pivots on the pivot mount 64 of the type wheel hanger, in a sudden movement which imparts a clockwise rotation to the type wheel 27 relative to the type wheel drive gear 28. As the high point of the cam lobe on the print cam 32 passes the cam follower 66 on the type wheel hanger 30, the lateral acceleration of the type wheel 27 toward the platen 22 is at a peak, although the selected type face 60 on the type wheel 27 is not quite in engagement with the paper 25. However, the counterclockwise rotation imparted to the type wheel 27 by the type wheel drive gear 28, and the clockwise rotation imparted by the lateral movement of the type wheel 27 are equal and opposite and the type wheel 27 has minimum rotation as its momentum impresses the selected type face 60 against the paper 25 and the platen 22. Thereafter, the biasing spring 65 immediately withdraws the type wheel hanger 30 and the type wheel 27 away from the print position.

The rotation of the print cam 32 continues for approximately another 90°, at which point the free end of the print clutch dog comes into engagement with the extended tab at the end of the print clutch latch 80, and the print cam 32 is again held stationary between the print cam detent 76 and the print clutch latch 80.

There are 48 type characters on the type wheel 27, and 12 teeth on the print clutch reamer 70, and a 1:4 speed ratio between the two rotating members, so that once a print cycle is started it is completed in one full revolution of the type wheel. This system does not utilize a 100 line-per-minute printing rate, however, because of the fact that there would not be adequate clutch relatch time if the last character in a cycle were immediately to be followed by the first character in the succeeding cycle. As seen in FIGS. 1 and 3, the relatch time requires a major part of a full rotation of the print clutch reamer 70.

The present system, as described above in FIG. 2, accounts for this eventuality by providing a full print clutch reamer 70 cycle for clutch latch time. Each four operative revolutions are followed by a further revolution in which data may be fed in, the carriage advance mechanism operate, and the clutch relatch operation effected. As described in conjunction with FIG. 2, the use of a definite and continuous correspondence between the characters generated by the code wheel and the storage of the actual characters in the buffer storage, permits this idle cycle to be completed without disruption of synchronous operation. Two or more cycles could be provided for this purpose, or on the other hand only a part of a cycle might also be used. In the present instance twelve characters are skipped as the print clutch reamer rotates one full revolution, and so the first character of the succeeding cycle is thereby shifted twelve characters each time. The result is that the system, operating with the given rotational rates, prints 80 lines per minute.

An important feature of systems in accoradnce with the invention is that they provide the equivalent of a continuously operating drum printer which is nonetheless a front printing mechanism. Accordingly, the characters are printed more clearly, and with better alignment, and the mechanism operates more quietly than other drum printers. In addition, the advantages of the type wheel hanger type of mechanism are retained, namely the use of a proven type wheel and actuating design and the elimination of relative movement between the type face and the paper and platen during imprinting.

Another important advantage of systems in accordance with the invention is derived from the use of 48 different print times, and the "ripple" printing afforded by the spiraled teeth on the print clutch reamer 70. Even if the same character is to be printed at all columns for a given line, the spiralling of the print clutch reamer 70 spreads the impact in time by a discernible amount. The delay between the printing of the same character adjacent print positions is approximately three milliseconds, and the total delay throughout the 120 positions is therefore in excess of a third of a second. The impact and wear on the platen 22 are thereby appreciably diminished, and the noise generated by the printing action is additionally decreased. In addition, because there are 48 distinct printing times there is a much greater distribution than heretofore of the impact forces which tend to disrupt both the paper and the platen mechanism. For these reasons, such additional elements as the platen lock and paper bands, which are used on the Type 407 printer, need not be employed. The system is easier to load and maintain because of the front printer arrangement, but nevertheless permits the use of many pre-existing parts, dies and manufacturing techniques.

The elimination of these parts, and other parts such as are utilized in a selector clutch mechanism heretofore employed with this type of printer, therefore greatly decreases the cost of the printer mechanism, while increasing its reliability. The mechanisms needed to maintain taut paper, and the excessive noise arising from the "drum beating" effect occurring with back printer devices, are completely eliminated. The equivalent of a drum printer, compatible with an electronic data processing system, is achieved through a simple and reliable control system operated in cooperation with the printer mechanism.

The same printer mechanism may of course also be employed in a single print wheel device, such as one which prints character messages on a paper tape. For most applications, however, the printer system and associated code wheel, buffer storage and controls, are best adapted to generation of line-at-a-time printed records from data provided in a standard computer format.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A drum printing system for printing characters a line at a time from characters generated parallel by bit and serial by character in an electronic data processing system, with the printing mechanism being substantially front mounted, comprising: a printing platen, paper carriage advance means for advancing paper about the platen, a plurality of type wheels individually mounted to rotate along a printing line adjacent the platen, a plurality of wheel hanger means, each supporting a different type wheel to permit urging of the type wheel against the paper and the platen, continuously operating drive gear means engaging continuously and rotating the type wheels, a plurality of print cams, each disposed adjacent a different one of the hanger means and each having a cam surface including a cam lobe movable to urge the hanger means towards the platen, print clutch reamer shaft means disposed within the plurality of print cams, the reamer shaft means being continuously rotating and having a plurality of teeth disposed in a spiral configuration along the axis of the reamer shaft means, a plurality of print clutch means for engaging the print cams to the reamer shaft means, a plurality of print magnet means for actuating the print clutch means, code wheel continuously means

rotating with the type wheels for providing binary code a sequence of patterns representative of the sequence of characters available for printing at the type wheels, data storage means for receiving characters parallel by bit and serial by character from an electronic data processing system, the characters for the data storage means constituting a full printing line, means coupled to the data storage means for recirculating all characters successively out of and back into the data storage means for each printing position of the type wheels, means for comparing each recirculated character to the binary patterns from the code wheel means to actuate the print magnet means at a corresponding column print position along the printing line and means responsive to the completion of a cycle of rotation of the type wheels for delaying the initiation of a succeeding print cycle by a predetermined fraction of the cycle of rotation of the type wheels.

2. The invention as set forth in claim 1 above, wherein the type wheels each have peripheral teeth and the drive gear means engage said peripheral teeth, the print clutch means each include print clutch dog means mounted on the print cam, the print cams being mounted about the reamer shaft means, pivotally mounted print clutch latch means normally maintaining the print clutch dog means out of contact with the reamer shaft means, a magnet armature knock-off lever normally blocking the print clutch latch in a first position to maintain the print clutch dog out of contact with the reamer shaft means, means responsive to the print magnet means for moving the magnet armature knock-off lever to a second position permitting disengagement of the print clutch latch from the print clutch dog, whereby the print clutch dog engages the cam to the reamer shaft means at a selected gear thereon, and a clutch relatch lever engaging the print cam means and pivoting the print clutch latch into a position of engagement with the print clutch dog, whereby the magnet armature knock-off lever is returned to its first position.

3. The invention as set forth in claim 2, above, wherein the type wheel hanger is pivotally mounted to permit a type wheel to move toward or away from the printing position, wherein the movements of the type wheel drive gear and the print cam impose opposite directions of rotation of the type wheel, such that the type wheel has no relative rotation relative to the platen when the type wheel engages the paper at the printing position, and wherein the number of teeth of the reamer shaft means have the same proportion to the number of characters of the type wheel as the rate of rotation of the type wheel to the reamer shaft means and wherein the predetermined fraction of a cycle consists of one full cycle of the reamer shaft means.

4. A system for line-at-a-time front printing from data provided in a standard computer format comprising the combination of means, including continually rotating and separately actuable type wheels, disposed adjacent a printing position; storage means coupled to receive data in the form of a number of binary patterns corresponding to a line of characters to be printed; means coupled to the storage means for recirculating all of the characters in the storage means for each printing character presented by the type wheels; character generating means, coupled to the type wheels, for generating binary patterns representative of characters then available for printing at the type wheels; means responsive to the means for recirculating and to the character generating means for comparing the binary patterns; cam means disposed adjacent each of the type wheels for urging the respective type wheels into engagement with a paper to be printed; means responsive to the means for comparing for operating the individual cam means in response thereto; and means responsive to the completion of a cycle of the type wheels for delaying the termination of printing of one line relative to the start of printing of the next by a fraction of a cycle of the type wheels to permit relatch of the cam means, paper shift and the introduction of new data.

5. A system for controlling line-at-a-time printing from data provided in a standard computer format comprising the combination of separately actuable printer elements having continuous cycles, disposed along successive columns adjacent a printing position; storage means coupled to receive a number of binary characters corresponding to a line of characters to be printed; means coupled to the storage means for recirculating all of the characters in the storage during predetermined parts of a cycle of the printer elements; character generating means, coupled to the printer elements, for generating binary patterns representative of the parts of the printer element cycles; means responsive to the means for recirculating and to the character generating means for comparing the binary patterns; actuating means disposed adjacent each of the printer elements; means responsive to the means for comparing for operating the actuating means; and means responsive to the character generating means and coupled to the means for comparing for shifting the starting point of the printer element cycles following each complete cycle.

6. The invention as set forth in claim 5 wherein the last-mentioned means comprises means responsive to the character generating means for counting the successive parts of a cycle of the printer elements, means responsive to the means for counting for identifying each full cycle from a starting point, and means responsive to the means for counting for delaying the next starting point for a predetermined fraction of a cycle.

7. A system for controlling a line-at-a-time printer from data provided in a standard computer format, including a plurality of continuously rotating printer elements, a plurality of separately operable actuating means, each for a different printer element, means for storing characters representative of a line to be printed, means coupled to rotate with the printer elements for generating character data for each successive character position of the printer elements as they are presented for printing, means for recirculating all characters in the means for storage during each character position of the printer elements, means for comparing the recirculating characters and the generated character data, means, including scanner means, for operating particular actuating means when a comparison exists, and means, including counter means, coupled to the means for generating character data and defining successive print cycles which are progressively shifted in time relative to printer element rotation.

8. A mechanism for typing characters on a record member in response to actuating signals provided with selected time displacements within operating cycles comprising, the combination of a type wheel having peripheral characters thereon, the type wheel periphery including gear means, a continuously rotating drive gear engaging the periphery of the type wheel and continuously rotating the type wheel at a selected first rotational speed, the type wheel having a selected number of characters thereon, pivotally mounted wheel hanger means supporting the type wheel for movement toward and away from the associated record member, while maintaining continuous engagement with the drive gear, a continuously rotating reamer shaft having a number of peripheral teeth, the reamer shaft having a rate of rotation which is related to the selected rate of rotation of the type wheel in the same ratio as the number of characters on the type wheel have to the number of teeth on the reamer shaft, a print cam encompassing the reamer shaft and including a cam lobe surface in operative relation to the wheel hanger, clutch means, including a dog mounted on the print cam, for engaging the print cam to the reamer shaft, clutch actuating means disposed adjacent the print cam for releasing the dog on the print cam to engage the reamer shaft for a single cycle of rotation of

the reamer shaft, energizing means for providing a signal to the clutch actuating means at a selected time within the type wheel revolution and means responsive to the rotation of the type wheel for blocking energization of the energizing means for a predetermined part of each cycle following a complete rotation of the type wheel.

9. A printing mechanism for a line-at-a-time printer comprising: a plurality of type wheels disposed along a selected axis near a printing line; a plurality of type wheel hangers, each supporting a different type wheel along the selected axis, and each movable toward the printing position; type wheel drive means continually engaging the type wheels, and continuously rotating the type wheels in a selected direction; a plurality of print cam means, each positioned to urge a different type wheel hanger toward the printing position; print cam drive shaft means having a number of peripheral teeth for engaging each of the print cam means, the cam drive shaft means having a rotational speed which is an integral multiple of the rotational speed of the type wheels, means for providing energizing signals for each of the print positions at selected times within the type wheel cycles, means responsive to the energizing signals for engaging the print cam means to the print cam drive shaft means at predetermined times within the cycle of revolution of the type wheels, and means for blocking energization of the means for providing energizing signals for a full cycle of the print cam drive shaft means following each full cycle of the type wheel means.

References Cited by the Examiner

UNITED STATES PATENTS

2,046,465	7/36	Knutsen	101—91
2,199,561	5/40	Fuller et al.	101—93
2,438,071	3/48	Page et al.	101—93
2,906,200	9/59	Pfleger	101—93
2,909,993	10/59	Shafer et al.	101—93
3,064,561	11/62	Mauduit	101—93

References Cited by the Applicant

UNITED STATES PATENTS

2,799,221	7/57	Olivetti.
2,915,968	12/59	Witt et al.
2,918,659	12/59	Gaddis et al.

ROBERT E. PULFREY, *Primary Examiner.*

WILLIAM B. PENN, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,215,070 November 2, 1965

Roger E. Abernathy et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 52, for "read write" read -- read-write --; column 8, line 14, for "of", second occurrence, read -- at --; column 9, line 55, for "operate" read -- operated --; column 10, line 64, for "continuously and" read -- and continuously -- line 75, for "continuously means" read -- means continuously -- column 11, line 2, strike out "a sequence of", and insert the same after "providing", in line 1, same column 11.

Signed and sealed this 13th day of December 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents