United States Patent [19]

Jones et al.

[11] **3,739,720**

[45] **June 19, 1973**

[54] **METHOD OF SELECTIVE HIGH SPEED PRINTING USING LETTERS WITH FLARED LIMBS AND GAPS TO COMPENSATE FOR SMEARING**

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[22] Filed: **Oct. 6, 1970**

[21] Appl. No.: **78,409**

[52] **U.S. Cl.** ..... **101/93 C**, 101/399, 101/426

[51] **Int. Cl.** **B41j 1/26**, B41b 1/02

[58] **Field of Search** ..... 101/93 C, 398, 399, 101/426; 64/12-14; 283/1; 197/83, 1 A, 2, 8

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[57] **ABSTRACT**

Printing methods and apparatus applicable to computer printing of the kind wherein a continuously rotating cylinder is provided with a plurality of rows of type characters operable to imprint paper or other print-receiving media through an ink transfer medium. The characters of each row of characters are identical and unlike the type characters in any other row and the array or arrangement of rows of characters is such with reference to the direction of rotation of the cylinder and the probable frequency of printing of the different characters in the printing of the composition that the characters are presented at a printing station in the order of increasing probability of printing. The type characters on the drum are so constructed with reference to the direction of rotation of the cylinder as to compensate for smearing of the printed characters due to wiping movement of the characters relative to the print-receiving medium and thereby enable the printed characters to present an appearance unmarred by smearing. Some of the type characters on the cylinder are adapted to overprint or be overprinted by other type characters so as to produce printed characters unlike any of the type characters on the cylinder, and others of the type characters are shaped to print characters having more than a single meaning. The type characters include upper case letters, lower case letters, numerals, punctuation marks, and special symbols by means of which a composition can be printed by the computer in virtually the same form as a typewritten composition.

18 Claims, 9 Drawing Figures

United States Patent [19]
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[11] **3,739,720**
[45] **June 19, 1973**

Patented June 19, 1973 3,739,720

5 Sheets-Sheet 1

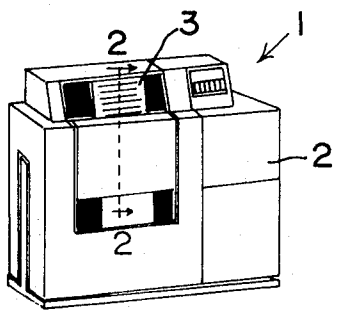

FIG. 1

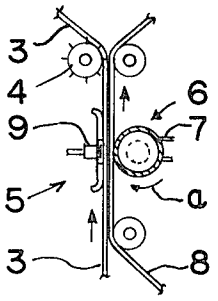

FIG. 2

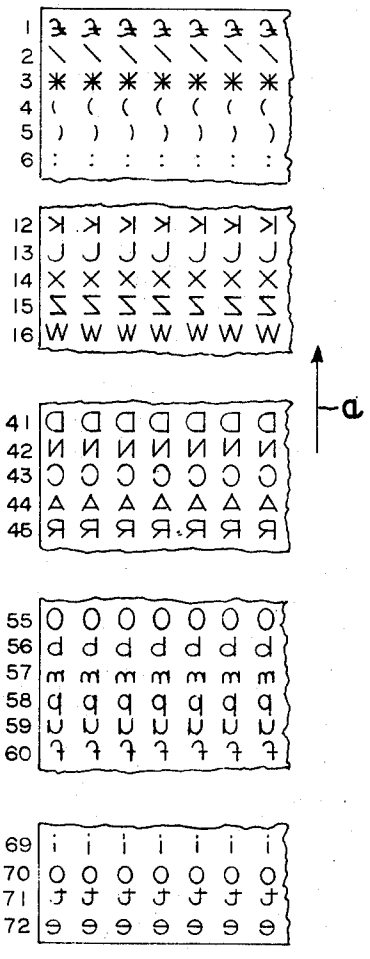

FIG. 4

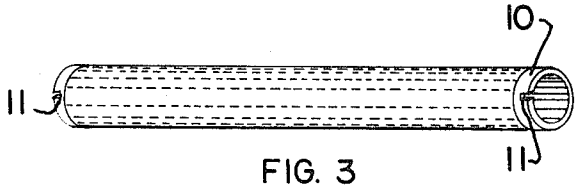

FIG. 3

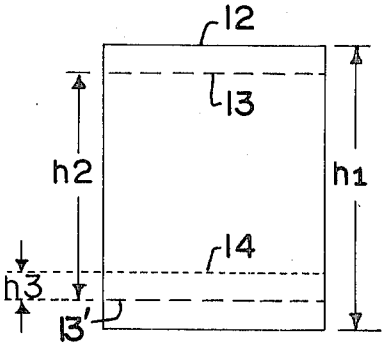

FIG. 5

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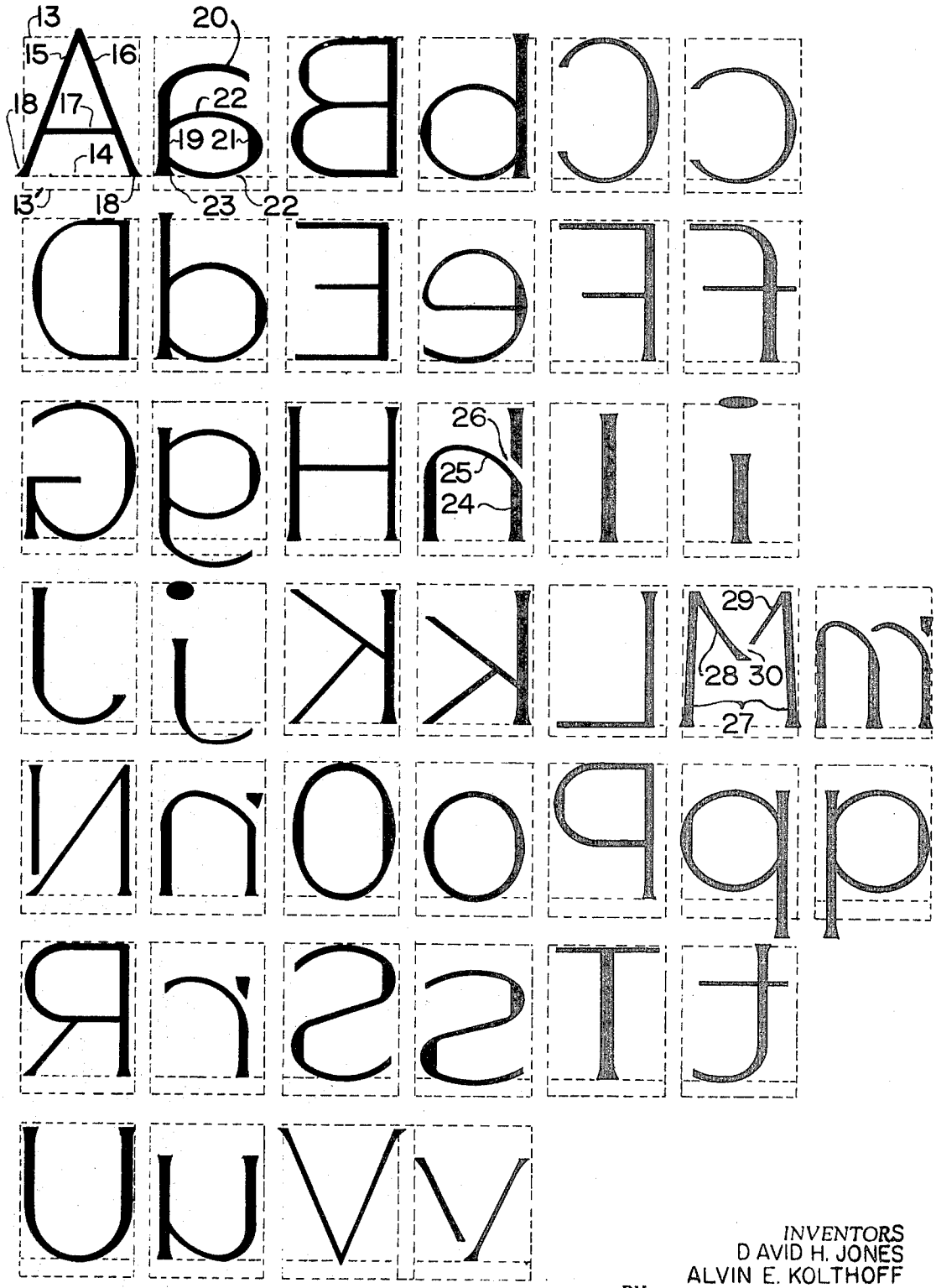

FIG. 6

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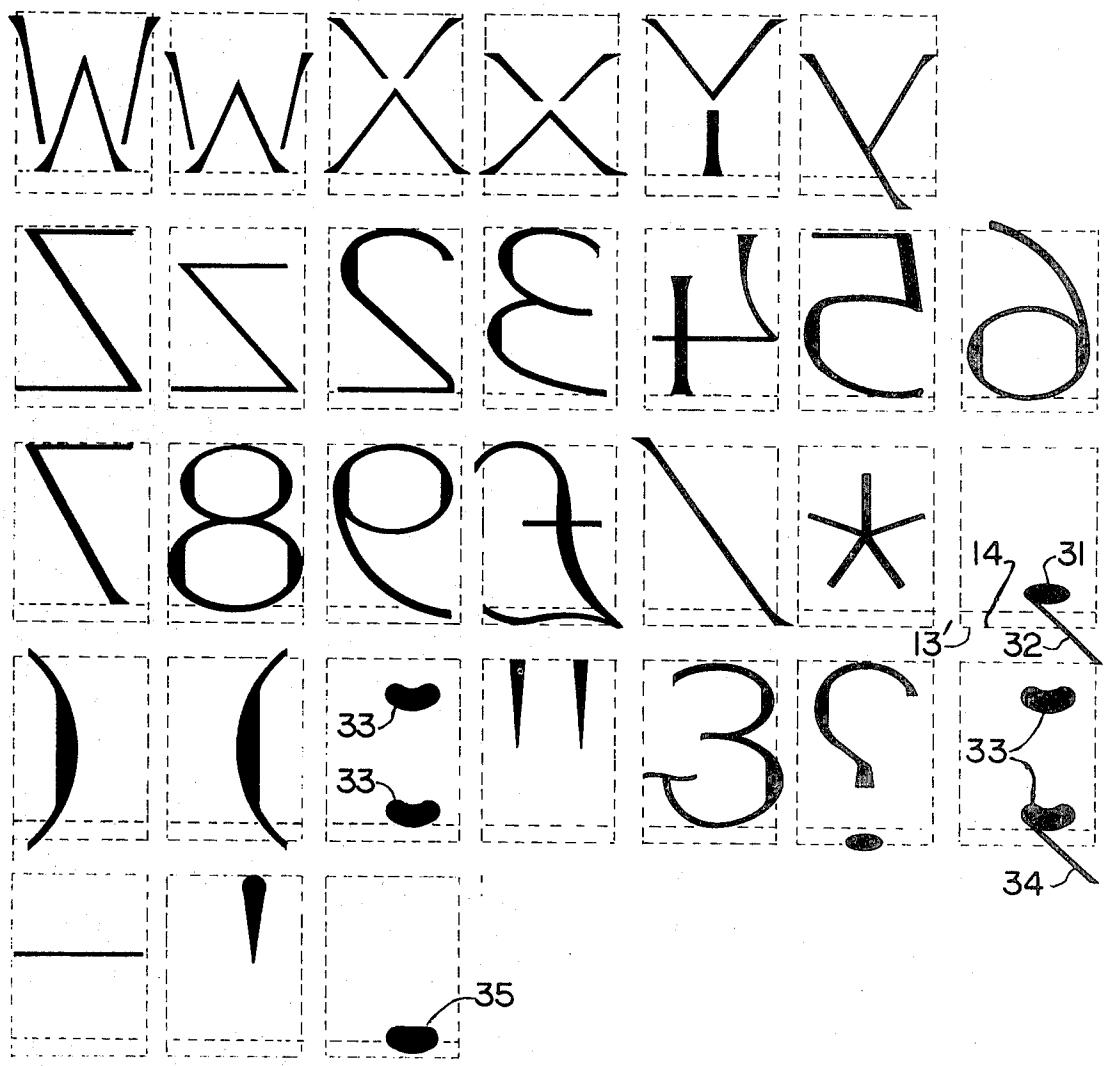

FIG. 7

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FIG. 8

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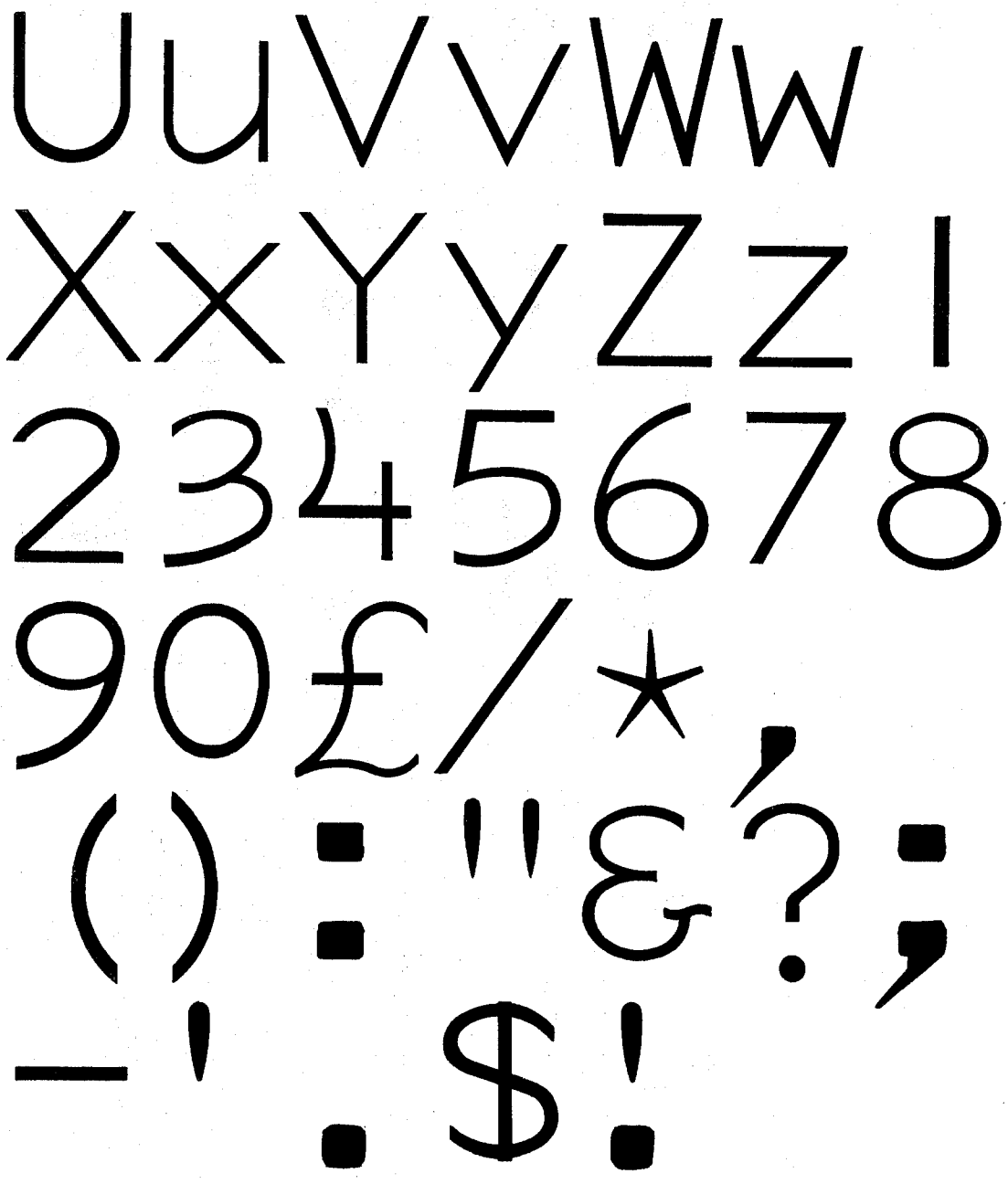

FIG. 9

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METHOD OF SELECTIVE HIGH SPEED PRINTING USING LETTERS WITH FLARED LIMBS AND GAPS TO COMPENSATE FOR SMEARING

The invention disclosed herein relates to computer printing and more particularly to the computer printing of compositions in a manner closely simulating typewritten compositions and still retain the speed of printing and flexibility of composition obtainable by the computer printer.

Computer printers have been in use heretofore for the printing of compositions such as business letters, particularly advertising letters, which simulate typewritten letters but differ from conventional, printed circular-type communications in that the computer printed letters can incorporate some personal characteristics such as the inclusion of the recipient's name in the body of the letter, as well as in the letter heading. Some of the computer printers currently in use have the ability to print at a rate approaching 1,500 printed lines per minute, but such printers do not utilize lower case alphabetic characters. Those computer printers which do utilize both upper and lower case characters operate at less than half the speed of those printers which utilize upper case characters only. Consequently, if it heretofore was desired to produce computer printed correspondence utilizing both upper and lower case letters, a great deal of the speed and efficiency of the computer was sacrificed.

Although it has been the objective of organizations utilizing computer printed correspondence to produce a composition having a quality and appearance approaching that of an individually typewritten letter, this objective has not been attained heretofore primarily because the carrier on which the printing type characters are supported moves relatively to the paper or other medium on which the composition is to be printed. Such movement causes wiping between the type character and the paper which results in smearing of the ink or other printing medium on the paper. Such wiping movement has several objectionable results. For example, those limbs of the printing surface of a type character which extend laterally of the direction of movement of the carrier cause the corresponding limbs of the printed character to be wider or thicker than the other limbs of the printed character. On the other hand, those limbs of the printing surface of a type character which extend generally in the direction of movement of the character also cause the corresponding limbs of the printed character to be smeared, but in this instance such limbs of the printed character are elongated, rather than widened, and frequently taper to needle-like points. It is common, therefore, for one or more limbs of a printed character to be considerably thicker than the other limbs thereof and for some characters to be considerably longer than other characters, even though the length of such characters ideally should be uniform. The result of the unavoidable smearing during imprinting, therefore, is that the aspect ratio between limbs of a single character and between different characters is irregular and unsightly.

The effect of wiping movement between the type character and the print-receiving medium and the resulting smearing of the printed character is especially noticeable and objectionable in the printing of alphabetic characters such as the lower case letters *a*, *e*, *g*, and the like, wherein the printed character should have a small, closed loop. Such loops are less than the overall height of the letter and, with type characters of the kind in use heretofore, it has been virtually impossible to prevent the filling in with ink of such loops of the printed characters due to the smearing caused by the wiping movement. As a consequence, computer printed correspondence utilizing lower case alphabetic letters has been objectionable from the standpoint of the appearance of such lower case letters.

The wiping movement between the type characters and the medium to be printed results in still another objectionable characteristic due to ink smearing. Those type characters having printing surfaces composed of character limbs which diverge in the direction of movement of the type carrier, such as the letters M, W, X, and the like, have a tendency to cause excessive ink smearing at the zone of convergence of such limbs with the result that the corresponding limbs of the printed character are not well defined, but instead, are bridged by a blot of ink. For example, at the zone of intersection of the limbs of the letter X printed by conventional type character constructions, the intersection of the limbs is obscured by an excessive quantity of ink, thereby resulting in an unattractive printed letter.

The arrangement or array of type characters on prior art carriers has varied from purely alphabetic and numeric sequencing to sequencing related to the most frequently used letters and numerals of a language. For example, some carriers have had their type characters arranged in alphabetical sequence, e.g., the character *a*, followed by the character *b*, followed by the character *c*, and so on, whereas other carriers have had their characters arranged according to the most frequently used characters, e.g., the character *e*, followed by the character *t*, followed by the character *o*, and so on. Although the latter array is more efficient, particularly in an asynchronous computer printer, it does not result in the most efficient arrangement of characters for all purposes. To illustrate this point, the lower case letter *e* is the most frequently encountered alphabetic letter in the English language, but this is not true with respect to the upper case letter E. Thus, if a type character carrier which is to be used for the printing of upper and lower case characters in the English language is to have its characters arrayed for the most efficient operation, the upper case E and the lower case *e* should not be located adjacent one another.

To illustrate further the importance of the array of characters on a type character carrier, the upper case letter D and the upper case letter Y will occur much more frequently in the printing of compositions such as business letters than in other compositions, due to the prevalence of the word "Dear" in correspondence salutations and the word "Yours" in the complimentary close. For the most efficient arrangement of type characters on a carrier, therefore, it is important to know the approximate relative number of occurrences of the different characters in a composition of the general class to be printed. When this is known, the probable relative frequency of printing of the different characters in the printing of the composition also will be known, thereby making it possible to arrange the type characters on the carrier in a sequence which has a definite relationship to the probable frequency of printing of the characters.

The probable frequency of printing of any given character will vary according to the class of composition that is to be printed and according to the language

in which it is to be printed. That is, although the lower case letter *e* is the most frequently used character in compositions such as business letters printed in English, it is probable that some other letter would be used more frequently in the printing of business letters in other languages, such as French, Italian, and Spanish.

The array of type characters on a carrier adapted for use in an asynchronous computer printer should be such as to conserve as much time as possible between the printing of the last character in a line of a page and the printing of the first character in the succeeding line of the page. It will be understood that printing does not occur during the time that the print-receiving page is indexed from one line to the next, but that the type character carrier continues to move during such indexing. Consequently, those rows of type characters which pass the printing station during paper indexing are not available for printing until such time as the paper indexing has been completed and the carrier has returned the passed characters to the printing station. In previously known type character carriers having the type characters arrayed with reference to the probability of use of the characters, the array has been one of decreasing probability of use with reference to the direction of movement of the carrier. For example, if the type characters are carried on a cylinder which rotates in one direction, then the array of characters on the cylinder is in the order of decreasing probability of use in the direction of rotation of the cylinder. Such an arrangement, however, is not the most efficient array of characters.

In any of the known computer printers having a continuously moving type character carrier, there is only so much space available for type characters. If the printer is to be used in the printing of compositions such as business letters and the like utilizing both upper and lower case characters, it is essential that the carrier have the capability of printing the 26 upper case letters of the alphabet; the 26 lower case letters of the alphabet; the 10 numeric characters; punctuation marks such as the comma, the period, the semicolon, the colon, the question mark, the apostrophe, the quotation marks, the exclamation point, the parentheses, the hyphen, and the slant line; and such symbols as the asterisk, the ampersand, and the dollar sign. Moreover, if the carrier is to be adaptable to all English correspondence, regardless of whether the recipient's economy is based on the dollar or the pound sterling, the carrier should include the pound sterling symbol. If all of these characters are included on a single carrier, the carrier would require 78 different characters. However, by utilizing sans-serif characters of the kind which enable one character to print more than a single character and which enable one character to overprint or be overprinted by another character so as to produce a character unlike either of the overprinted characters, it is possible to print 78 characters with fewer than 78 type characters.

An object of this invention is to provide apparatus and methods for computer printing which overcome the disadvantages of previously known methods and apparatus and which are more efficient than previously known methods and apparatus.

Another object of the invention is to provide a computer printing type carrier adapted for continuous movement and wherein the type characters are so configured as to compensate for smearing of the printed characters due to wiping engagement between the type characters and the print-receiving medium.

A further object of the invention is to provide a type character carrier and method for computer printing and wherein the characters are arrayed on the carrier in such manner with reference to the direction of movement of the carrier that the characters are presented to the printing station in the order of increasing probability of use with reference to the direction of movement of the carrier.

A further object of the invention is to provide a type character carrier for printing computers and wherein the characters are so constructed as to enable selected ones thereof to print more than a single character and to enable certain characters to overprint others to produce characters unlike any of the overprinted characters, thereby providing a full range of characters required for the printing of a composition without necessitating the provision of each such character on the carrier.

Another object of the invention is to provide a type character carrier for printing computers which is interchangeable with other carriers and which includes both upper and lower case letter characters to enable the printing of both upper and lower case alphabetic letters without impairment of the efficiency of the computer printer.

Other objects and advantages of the invention will be pointed out specifically or will become apparent from the following description when it is considered in conjunction with the appended claims and the accompanying drawings, in which:

FIG. **1** is an isometric view of a computer printer of known construction with which apparatus constructed according to the invention is adapted to be used;

FIG. **2** is a diagrammatic, sectional view taken on the line **2—2** of FIG. **1**, and illustrating the printing apparatus incorporated in the computer printer shown in FIG. **1**;

FIG. **3** is a perspective view of a type character carrier constructed according to the invention, the scale of the figure being too small to permit identification of the characters supported thereon;

FIG. **4** is a fragmentary, enlarged, developed plan view of the surface of the carrier shown in FIG. **3** and illustrating in part the arrangement of the characters on the carrier, but not illustrating the specific configuration of the characters;

FIG. **5** is a diagrammatic view illustrating the relative sizes of a printing hammer of the computer printer and the area within which a type character on the carrier is confined;

FIGS. **6** and **7** are plan views, on a greatly enlarged scale, of the printing surfaces of type characters constructed according to the invention and supported on the carrier of FIG. **3**; and

FIGS. **8** and **9** are plan views of the characters printed by the type characters of FIGS. **6** and **7**.

Printing in accordance with the principles of the invention is effected by means of a continuously moving carrier on which type characters are supported for transient repetitive presentation to a printing station at which is positioned a print-receiving sheet and an ink transfer medium through which a selected character prints in response to the effecting of a printing impression between the print-receiving sheet and the type

character. Due to the continuous movement of the type character carrier the character being imprinted will have wiping movement relative to the print-receiving sheet which inevitably will cause smearing of the ink transferred from the ink transfer medium to the print-receiving sheet. The type characters on the carrier are distorted in such manner as to compensate for smearing of ink on the sheet to be printed and the distortion of the type characters is of such nature with respect to the speed and direction of movement of the carrier that the characters printed on the sheet are not distorted, but instead have a uniform, regular, well-defined appearance.

Each of the characters, whether it be upper or lower case alphabetic, numeric, or other, is subjected to distortion of a similar nature, but not all characters need be distorted to the same degree inasmuch as some characters, such as the upper case M, are much larger than others, such as the lower case *i*. The degree of distortion of each individual character, therefore, is such that the aspect ratio or appearance of each printed character with reference to the others is balanced with respect to overall size and line thickness.

The array of characters on a carrier constructed in accordance with the invention is such that characters presented to a printing station are presented in the order of increasing probability of printing, the particular array being selected from a data base determined from the sampling of a large number of compositions printed in the language that is to be used in the printing of similar compositions by the carrier according to the invention.

Apparatus and methods according to the invention are disclosed in conjunction with a Century Series computer printer **1** manufactured by the National Cash Register Company, of Dayton, Ohio, and particularly the 640–200 Century printer. The operating characteristics and other pertinent information relating to the printer are disclosed in the manufacturer's publications, such as the Product Information Bulletin relating to Century Series printers forming part of the NCR Reference Manual published in August, 1968, and to which reference may be had for a more detailed description of the printer itself. Briefly, however, the printer **1** includes a cabinet **2** within which is contained a print-receiving medium such as a continuous sheet **3** or pack of sheets which is indexed upwardly, as viewed in FIG. **1** in increments of either six or eight lines to the inch, according to the kind of printing operation to be performed. The sheet indexing is accomplished by means of sprockets, one of which is shown at **4**, which engage perforations in the sheets and advance the latter incrementally to a printing station **5** at which is mounted a typeline or carrier **6** on which is embossed a plurality of axial rows of type characters and which is rotated continuously at the rate of 1,500 r.p.m. in the direction of the arrow *a* by a suitable drive belt **7** or the like. Interposed between the sheet **3** and the carrier **6** is an ink transfer medium **8** which may comprise an inked ribbon or sheet which is unwound from one spool onto another by the ribbon winding mechanism (not shown). At the printing station **5** is a row of solenoid operated printing hammers **9**, there being one such hammer for each type character in a row on the carrier **6**, and each of the hammers is adapted to be actuated under the control of an optical sensing code disc (not shown) to move toward the carrier **6** so as to effect a printing impression between the hammer and the associated type character on the carrier **6** and effect an ink transfer from the ribbon **9** to the sheet **3**.

The Century computer printer is furnished by the manufacturer with a typeline or type character carrier **6** having 64 rows of type characters and which is removable so as to enable any one of a plurality of carriers to be used interchangeably with the same printer. Although a carrier constructed according to the invention differs in many respects from the carriers furnished by the printer manufacturer, the carrier of the invention is interchangeable with the manufacturer's carriers and requires no modification of the printer other than the substitution of a code disc which is like the original code disc but is adapted to operate the print hammers in 72 rows of characters, rather than 64, and the associated electrical wiring of the code disc. These modifications of the printer are simple and are well understood by those working in the computer printing art, and it therefore is not deemed necessary to an understanding of the invention to include a further description of the printer itself.

A typeline drum or type character carrier constructed according to the invention is designated generally by the reference character **6** and comprises an elongate, metal cylinder **10** having notches **11** at its opposite ends for accommodation of driving lugs driven from the driving means **7** of the printer **1**. The outer surface of the cylinder or drum has embossed thereon a plurality of axially extending rows of type characters, the rows being arranged substantially uniformly about the periphery of the drum and, in the disclosed embodiment, there are 72 rows of type characters. Each row of characters contains the same number of characters and each character in a row is identical. The characters in any one row, however, are different from the characters in the remaining rows. The number of characters in each row may vary, but preferably there are 160 characters in each row and each character is located in a space having an axial width of 0.1 inch. The total length of each row of characters, therefore, is 16 inches. The carrier thus is capable of printing a line up to 16 inches in length. In practice, it is possible to print simultaneously two ordinary business letters side-by-side on sheets measuring 8½ inches wide.

The height of a character in any one of the rows is limited by two factors. First, the height of the character is limited by the necessity of providing space between the rows of characters so as to avoid shadowing during printing caused by a hammer **9** effecting not only a printing impression of the character to be printed, but also some portion of the characters in the adjacent rows. Second, the height of a character is limited by the corresponding dimension of the hammer by means of which a printing impression of the character is obtained. These factors are indicated in FIG. **5** wherein a solid line block **12** represents the area of each printing hammer **9**. The width of the hammer is 0.08 inch and its height h_1 is 0.120 inch. The nominal maximum height h_2 of a character is represented by two broken lines **13** and **13'** spaced 0.100 inch apart. The width of the character may conform to the width of the hammer **9**.

Virtually all languages include at least one character having a portion thereof which normally extends below the bottom of a printed line. In the English language, for example, characters such as the lower case *g*, the

lower case *p*, the lower case *q*, and the like, have portions which, when printed, extend to a level below the level of other characters in a printed line. Conventional computer printing does not provide for this characteristic and, consequently the characters printed by conventional computer printing mechanisms do not have the desired aspect ratio. Type characters constructed according to the invention, however, provide for such characteristics by establishing for each character a base line, indicated by the dotted line **14** in FIG. **5**, located at a height h_3 above the bottom line **13'**. All characters except those having portions adapted to extend below the bottom of other characters in a printed line have their lowermost edges located adjacent the base line **14**. The base line **14** is located 0.010 inch above the bottom line **13'**. The nominal height of the remaining characters thus is 0.09 inch.

A drum **10** constructed according to the invention for printing correspondence in the English language must include, at the minimum, sufficient type characters to print the 26 upper case letters of the alphabet, the 26 lower case letters of the alphabet, the 10 digits, at least some symbols, and sufficient punctuation marks to enable conventional correspondence to be printed grammatically. The upper and lower case alphabetic characters and the numeric characters alone total 62, thereby necessitating the provision of 62 rows of characters on the drum. A typeline drum adapted for use iwth the Century 640–200 printed may have a maximum diameter of only 3.25 inches. It is impossible, therefore, to provide sufficient rows of characters on such drum to accommodate the 62 alphabetic and numeric characters and still provide the punctuation mark and other characters required to print grammatical correspondence. This problem has been solved according to the invention by selecting a type face which enables certain characters to be shared, i.e., a single character has more than one meaning, and which has certain characters that can overprint or be overprinted by other characters so as to produce characters unlike any of the overprinted characters. One type face which possesses these characteristics is the Artesian **10** type face which has sans-serif alphabetic and numeric characters. The Artesian **10** type face enables the upper case I to serve also as the lower case *l* and the numeral 1. It also permits the upper case O to serve as the numeral 0. The upper case I also can be overprinted by, or overprint, the upper case S to form the dollar symbol. The upper case Q can be formed by overprinting the upper case O with the comma, which results in the tail of the Q curling to the left, rather than to the right, but nevertheless is a recognizable Q. The exclamation point can be printed by overprinting the apostrophe and the period.

The sharing of characters as indicated above, coupled with the ability of certain other characters to be overprinted, enables the number of alphabetic characters required on the drum to be reduced from 52 to 50, the number of numeric characters to be reduced from 10 to eight, and makes it unnecessary to provide characters corresponding to the dollar symbol and the exclamation point. Thus, 14 characters comprising the pound sterling sign, the slant line, the asterisk, the comma, the two parentheses, the colon, the quotation mark, the ampersand, the question mark, the semicolon, the hyphen, the apostrophe and the period may be included on the drum, making a total of 72 different characters and, consequently 72 different rows of characters. The character sharing and overprinting characteristics, however, make it possible for the 72 type characters to print a total of 78 different characters. The 72 rows of characters may be provided on the 3.25 inch diameter drum without causing the objectionable shadowing.

FIG. **4** indicates the developed surface of the drum **10** and illustrates in part the array or arrangement of the rows of characters on the drum. The drum **10** is asynchronous and, therefore, strictly speaking has no beginning row of characters. However, for the purpose of illustration the rows of type characters illustrated in FIG. **4** have been assigned numbers **1** through **72**, the numbers increasing in the direction of rotation of the drum **10**. Thus, if it is assumed that the rotation of the drum **10** is such as to effect movement of the rows of type characters past the printing station **5** in the direction of the arrow *a*, and if the row containing the pound sterling symbol happens to be the first row to arrive at the printing station, then the row containing the pound sterling symbol can be considered row **1**, with each succeeding row having the next higher number.

The type character selected for inclusion in a particular row is an important consideration inasmuch as the printing speed and efficiency of the printer is directly related to the order in which the type characters are presented to the printing station. The particular arrangement of the rows of characters may be determined by counting the number of times characters occur in compositions of the kind that are to be printed by the computer printer. Thus, if the printer is to be used for the printing of business letters in the English language and intended to be mailed to persons residing in the United States, a typical letter would include alphabetic characters, numeric characters, punctuation marks, and symbols such as the dollar sign. By counting the frequency of occurrence of individual characters in a large number of such letters, the probability of occurrence of similar characters in correspondence to be printed by the computer printer will be known and a data base will be established. The type characters then can be arranged on the drum **10** in an order having a direct relationship to the probability of their being printed.

The arrangement of characters illustrated in FIG. **4** was selected for the purpose of writing most efficiently business letters in the English language directed to a person residing in the United states. From the data base determined by the examination of a large number of similar letters it was determined that the most frequently encountered character in such letters is the lower case *e*, and the most infrequently encountered character is the pound sterling symbol. The second most frequently encountered character is the lower case *t*, and the second least frequently encountered character is the slant line. The characters on the drum **10** have been arranged, with reference to the direction of movement of the drum, in the order of increasing probability of printing. That is, the least likely character to be printed, the pound sterling symbol, occupies row number **1**, the next least likely to be printed character, the slant line, occupies row **2**, whereas the most likely character to be printed, the lower case *e*, occupies row **72** which is adjacent row **1**.

As has been indicated earlier, the type character drum **10** rotates continuously at the printing station **5**,

but no printing occurs during the indexing of the sheet 3 from line to line. During the indexing of the sheet 3 from one line to another, several rows of type characters pass the printing station. If the printing of a line of the composition requires any of the characters in the passed rows, the printing of the line cannot be completed until the drum has rotated a distance sufficient to present those characters to the printing station. It has been found that the arranging of the type characters on the drum in the order of increasing probability of printing produces a significant increase in the rate at which a composition can be printed.

The array or arrangement of type characters on the drum **10** is as follows:

Row	Character	Row	Character	Row	Character
1	Special "£"	26	Numeric "6"	51	Special "."
2	Special "/"	27	Numeric "3"	52	Upper Case "T"
3	Special "*"	28	Upper Case "U"	53	Lower Case "y"
4	Special "("	29	Upper Case "p"	54	Special ","
5	Special ")"	30	Upper Case "V"	55	Upper Case "O"
6	Special ":"	31	Numeric "9"		Numeric "0"
7	Special "'"	32	Upper Case "L"	56	Lower Case "b"
8	Special "&"	33	Upper Case "H"	57	Lower Case "m"
9	Special "?"	34	Special "-"	58	Lower Case "p"
10	Upper Case "Z"	35	Upper Case "F"	59	Lower Case "u"
11	Special ";"	36	Lower Case "k"	60	Lower Case "f"
12	Upper Case "K"	37	Lower Case "x"	61	Lower Case "d"
13	Upper Case "J"	38	Upper Case "M"	62	Lower Case "c"
14	Upper Case "X"	39	Special "'"	63	Lower Case "h"
15	Lower Case "z"	40	Numeric "2"	64	Lower Case "l"
16	Upper Case "W"	41	Upper Case "D"		Upper Case "I"
17	Upper Case "Y"	42	Upper Case "N"		Numeric "1"
18	Upper Case "G"	43	Upper Case "C"	65	Lower Case "r"
19	Lower Case "j"	44	Upper Case "A"	66	Lower Case "s"
20	Lower Case "q"	45	Upper Case "R"	67	Lower Case "n"
21	Numeric "8"	46	Lower Case "v"	68	Lower Case "a"
22	Upper Case "B"	47	Upper Case "S"	69	Lower Case "i"
23	Numeric "5"	48	Lower Case "w"	70	Lower Case "o"
24	Numeric "7"	49	Upper Case "E"	71	Lower Case "t"
25	Numeric "4"	50	Lower Case "g"	72	Lower Case "e"

It should be borne in mind that the foregoing arrangement of characters has been selected for the printing of business letters in the English language and for sending to persons whose country's economy is based on the dollar. Should the printing drum be intended to print other kinds of compositions in other languages, the array of type characters on the drum will be different from the disclosed array, but in each instance the array of characters on the drum should be in the order of increasing probability of printing.

In the printing of compositions by means of a continuously rotating type character carrier or drum, the printing impression has a duration which is instantaneous, but there nevertheless is relative movement of the drum and the print-receiving sheet during the printing impression due to the continuously transient movement of the drum. The rotation of the drum thus results in wiping movement between a type character being printed, the ink transfer medium **8**, and the print-receiving medium **3**. As a result of the wiping movement, the ink transferred to the sheet **3** inevitably is smeared in the direction of wiping movement of the type character.

The smearing of the ink produces objectionable printed characters when the printing is done with conventional type character constructions. For example, in the printing of an alphabetic character such as the sans-serif upper case I, movement of the printing hammer toward the drum effects a gradually increasing printing pressure with the type character, whereas movement of the printing hammer away from the drum following the printing impression effects a gradual decrease of the printing pressure. The result of this when using conventional type characters carried by a rotating drum is that the printed character is needle-pointed at its opposite ends.

Another objection encountered in computer printing with conventional type character designs is that the wiping movement referred to hereinbefore causes the loops of alphabetic characters such as the lower case *a*, the lower case *e*, the lower case *g*, and the like, to be filled with ink, whereas other characters, such as the lower case *i* and the lower case *j*, have no clear demarkation between the dots and the upper end of the vertical limbs of the characters. Still another objection is that conventional type characters having limbs which extend laterally of the direction of wiping movement, such as the horizontal limbs of the upper case E and the hyphen, print characters in which theh horizontal limbs are much thicker or wider than the vertical limbs, thereby resulting in an unbalanced aspect ratio between the vertical and horizontal limbs.

Type characters constructed in accordance with the invention are distorted in such manner as to compensate for the smearing due to wiping movement between the type character and the print receiving medium. The smear compensating characteristics of the type characters are four in number. First, the free ends of the limbs of type characters that are to print vertical limbs of printed characters are flared laterally of the direction of wiping movement so as to prevent the limbs of the printed characters from being needle-pointed. Second, the vertical limbs of the type characters are made thicker or wider than the horizontal or lateral limbs by an amount such that the smearing resulting from the wiping movement will result in all limbs of the printed character being of substantially uniform width. Third, gaps are provided between intersecting limbs of a type character so as to avoid the smearing of ink into the included angle between the intersecting limbs, but the size and location of the gaps are such that the corresponding limbs of the printed character appear to be joined. Fourth, the overall height of the type character is less than the overall height of the character printed thereby by an amount such that the smearing due to wiping movement causes the printed character to have the desired height.

The smear compensating characteristics referred to above are illustrated in FIGS. **6** and **7** which disclose each type character on the carrier **10** and its location with respect to the height and base lines **13** and **14**, respectively. The upper case type character A has a printing surface composed of two upwardly converging limbs **15** and **16** that are joined by a cross limb **17**. The cross limb **17** is transverse to the direction of wiping movement which occurs between the type character and the print-receiving sheet **3** and, accordingly, is of less width than that of the limbs **15** and **16**. The upper ends of the limbs **15** and **16** are joined and extend slightly above the upper height line **13**. The lower ends of the limbs **15** and **16** terminate slightly above the base line **14** and are flared as at **18** laterally of the direction of wiping movement. Because the limbs **15** and **16** are themselves inclined to the direction of wiping movement, and thus result in smearing of the ink toward the bottom of the printed character, the free ends **18** need be flared only at the outer surfaces of the limbs.

The printing surface of the lower case *a* type character has a limb **19** a substantial portion of which is parallel to the direction of wiping movement and which merges at its upper end with a limb **20** which is trans-

verse to the direction of wiping movement. The limb **20,** therefore, is substantially thinner than the limb **19.** The loop of the lower case *a* has a limb portion **21** which extends generally parallel to the direction of wiping mvement. This limb portion, therefore, is made wider than the other limb portions **22** of the loop. The lower end of the limb **19** is free and is flared as at **23** on both sides.

The principles of construction referred to in connection with the upper and lower case characters A and *a*, respectively, are incorporated in all of the other characters, as will be apparent from the drawings. In general, those characters having limbs which are parallel to the direction of wiping movement have a greater width than that of limbs which extend laterally of the direction of wiping movement; the free ends of limbs that are parallel to the direction of wiping movement are flared laterally on both sides of the printing surface; limbs parallel to the direction of wiping movement and which do not have free ends are not flared; and limbs which are inclined to the direction of wiping movement and have free ends are flared on one side of the printing surface only.

The precise differences in width between the limbs of any character, the extent of flaring of the flared ends, and the exact height of a character, or portions thereof, are directly related to the speed of the wiping movement and the duration of the printing impression. Such dimensions can be determined empirically only, but for purposes of illustration, if a limb parallel to the direction of wiping movement has a width of about 0.004 inch, a limb transverse to the direction of wiping movement may have a width of about 0.001 inch, a limb inclined to the direction of wiping movement may have a width of about 0.002 inch, and the free end of a flared limb may have a maxium width of 0.006 inch. These dimensions are representative only, and changes may be made to provide the desired aspect ratio between the printed characters. For example, the upper case type character I has a minimum width greater than that of other vertical limbs, as a result of which the printed upper case I has a better appearance in relation to the other characters.

Some of the alphabetic characters have printing surfaces composed of limbs which extend along converging lines forming an included angle. In most instances in which the respective limbs converge toward the trailing end of the type character, i.e., opposite the direction of wiping movement of the character, and form an included angle of more than about thirty degrees, the wiping movement causes the smearing of ink into the space between the converging limbs at their zone of convergence and thus causes the printed characters to be unsightly in that they include a blot of ink between the converging limbs. Such characters include, inter alia, the lower case *h*, the upper and lower case M, the upper and lower case N, and the lower case *r*.

Type characters constructed accordlng to the invention are configured in such manner as to prevent the smearing of ink between converging limbs of the printed characters so as to enable the juncture of such limbs to be sharply defined. In the lower case *h*, for example, the printing surface includes a limb **24** which is parallel to the direction of wiping movement and a cross limb **25** which joins the limb **24** and extends laterally of the direction of wiping movement. At the juncture of the limbs **24** and **25** is a gap **26** which parallels the limb **25** and is formed in the limb **24** at the leading side of the limb **25** with reference to the direction of wiping movement. In the printing of a character by the lower case *h* type character, ink is smeared into the gap **26** so that, in the printed lower case *h*, the limbs **24** and **25** are joined.

The upper case M character has a printing surface comprising a pair of limbs **7** which extend substantially parallel to the direction of wiping movement and a pair of other limbs **28** and **29** which converge toward one another in a direction opposite that of the wiping movement. To prevent the blotting of ink in the space between the printed character's limbs which correspond to the limbs **28** and **29,** the limb **29** terminates short of convergence with the limb **28** to provide a gap **30** located at the leading side of the limb **28.** In the printing of the character, ink will be smeared into the space that otherwise would correspond to the gap **30** so that the limbs of the printed character corresponding to the limbs **28** and **29** are joined. It is not necessary to provide gaps between the limbs **27** and **28** and **29** inasmuch as such limbs converge in the direction of wiping movement, rather than in the opposite direction.

The considerations referred to above in connection with the gapping of the characters *h* and M apply in most, but not all, instances to those characters having printing limbs converging opposite the direction of wiping movement and forming an included angle of more than about 30 degrees. In some instances, however, it is not essential to provide gaps between the converging limbs. For example, the intersecting limbs of the upper case V and such limbs of both the upper case and the lower case K need not be gapped inasmuch as the overall height of the printed character minimizes the effect of the ink blotting. For the same reason, the converging limbs of the upper case Y character need not be gapped, but a gap is provided between the converging limbs and the vertical limb. The necessity for the provision of a gap is determined from inspection of the printed characters.

The length of a gap formed in a type character is determined by the appearance of the printed character and is thus directly related to the speed of wiping movement. Although the sizes of gaps provided in different type characters will vary, the length of a gap normally is substantially greater than the minimum width of the limb on the trailing edge of the gap.

One of the difficulties encountered heretofore in computer printing is that the comma occupies a position that is too high in the printed line and, in some instances, the printed comma has been confused with the numeral 1. The comma character constructed according to the invention is shown in FIG. **7** and has a printing surface comprising an elliptical limb **31,** with the major axis of the ellipse transverse to the direction of wiping movement, and a downwardly inclined limb **32** which is of considerably less width than that of the limb **31.** The limb **31** is located adjacent the base line **14** and the limb **32** extends below the bottom line **13'** so as to assure that the tail of the printed comma will be below the line of the bottoms of other characters in the printed line.

A colon character constructed according to the invention also is shown in FIG. **7** and includes two generally elliptical limbs **33** having their longitudinal axes extending transversely of the direction of wiping movement and being concave in the direction of wiping

movement. The semicolon character has limbs 33 like those of the colon character, but the lower limb 33 has joined thereto a downwardly inclined limb 34 like the comma limb 32.

The period character is shown in FIG. 7 and is similar to the limbs 33 of the colon character with the exception that the leading edge of the period limb 35 is horizontal, rather than concave. The purpose of this construction is to enlarge the area of the period character so as to avoid perforating the ink transfer medium 8.

Although the printing type characters themselves are distorted by the flaring of the free ends of the printing limbs which extend in the direction of the wiping movement, and by the provision of gaps between converging limbs, and by elliptical shaping, the distortions do not appear in the characters printed by the type characters. Instead, the printed characters conform to the Artesian 10 type face. The appearance of characters printed by type characters constructed according to the invention are shown in FIGS. 8 and 9.

This disclosure is representative of presently preferred methods and apparatus, but is intended to be illustrative rather than definitive of the invention. The invention is defined in the claims.

What is claimed is:

1. A method of printing a character on a print-receiving medium by means of a type character on a carrier which is movable relatively to said print-receiving medium for presenting said type character in printing position relative to said print-receiving medium, said type character having a printing surface one limb of which extends generally in the direction of movement of said carrier and has at least one free end which flares laterally of said direction of movement, whereby said free end of said limb has a width greater than that of the remainder of said limb, said method comprising positioning a smearable transfer medium between said carrier and said print-receiving medium; moving said carrier relatively to said print-receiving medium to present said type character transiently in printing position; and effecting printing pressure between said type character and said print-receiving medium through said transfer medium when said type character is transiently presented in printing position during movement of said carrier whereby to produce relative wiping movement between said type character, said transfer medium, and said print-receiving medium in the direction of movement of said carrier, said wiping movement causing smearing of said transfer medium on said print-receiving medium, the extent of lateral flaring of said free end of said limb being so selected with reference to the extent of said smearing that the character printed on said print-receiving medium has a limb corresponding to said one limb but has the appearance of substantially uniform width laterally of the direction of such relat1ve movement.

2. A method according to claim 1 wherein both ends of said limb of said type character are free and both of said free ends are flared similarly.

3. A method according to claim 1 wherein said free end of said limb of said type character is flared on both sides of said limb.

4. A method according to claim 1 wherein said free end of said limb of said type character is flared on one side only of said limb.

5. A method according to claim 1 wherein the length of said type character limb in the direction of movement of said carrier is less than the length of the corresponding limb of the character to be printed on said print-receiving medium.

6. A method according to claim 1 wherein said type character limb is joined to a second limb which extends laterally of the direction of movement of said carrier and wherein said second limb has a width in the direction of said movement less than the width of said remainder of the first-mentioned limb.

7. A method according to claim 1 wherein the printng surface of said type character includes a second limb which extends laterally of the direction of movement of said carrier and wherein said one limb has a width greater than the width of said second limb, the relative widths of said one and said second limbs being so related to the extent of said smearing that the character printed on said print-receiving medium has limbs corresponding to said one limb and said second limb but have the appearance of substantially uniform width.

8. A method according to claim 1 wherein said type character has at least one other limb extending laterally of the direction of movement of said carrier from adjacent the first-mentioned limb and spaced therefrom by a gap, said gap being of such length with respect to the extent of said smearing that the limbs of the character printed on said medium by said type character have the appearance of being joined.

9. A method according to claim 8 wherein said limbs of said type character form an included angle greater than about 30°.

10. A method according to claim 1 wherein siad carrier comprises a continuously rotating cylinder.

11. A method of printing a character on a print-receiving medium by means of a type character on a carrier which is movable relatively to said print-receiving medium for presenting said type character in printing position relative to said print-receiving medium, said type character having a printing surface comprising a pair of limbs which extend along lines converging generally opposite the direction of movement of said carrier and terminate short of intersection to form a gap between said limbs extending substantially in the direction of movement of said carrier, said method comprising positioning a smearable transfer medium between said carrier and said print-receiving medium; moving said carrier continuously relatively to said print-receiving medium to present said type character transiently in printing position; and effecting printing pressure between said type character and said print-receiving medium through said transfer medium when said type character is transiently presented in printing position whereby to produce relative wiping movement between said type character, said transfer medium, and said prnt-receiving medium in the direction of movement of said carrier, said wiping movement causing smearing of said transfer medium on said print-receiving medium, the size of said gap being so selected with reference to the extent of said smearing that the character printed on said print-receiving medium has limbs corresponding to said pair of limbs but which have the appearance of intersecting one another.

12. A method according to claim 11 wherein one of the limbs of said type character extends generally in the direction of said movement and the other of said limbs of said type character extends laterally of the direction of said movement.

13. A method according to claim **12** wherein the limb extending generally in the direction of said movement terminates short of said other of said limbs to form said gap.

14. A method according to claim **11** wherein said included angle is more than about 30 degrees.

15. A method according to claim **90** wherein said carrier comprises a cylinder rotatable about its longitudinal axis.

16. A method according to claim **15** wherein one limb of said type character extends substantially normal to said axis of rotation and the other of said limbs extends laterally of said axis.

17. A method according to claim **16** wherein the limb extending substantially normal to said axis of rotation has a width greater than the width of said other limb.

18. A method according to claim **17** wherein the relative widths of said limbs of said type character are so related to the extent of said smearing that the widths of the limbs printed on said print-receiving medium have the appearane of substantial uniformity.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,739,720 Dated June 19, 1973

Inventor(s) David H. Jones and Alvin E. Kolthoff

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 15, line 7, for "90" read -- 11 --.

Signed and Sealed this

thirteenth Day of *January 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks