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EFFICIENT JUSTIFICATION QUALITY CONTROL

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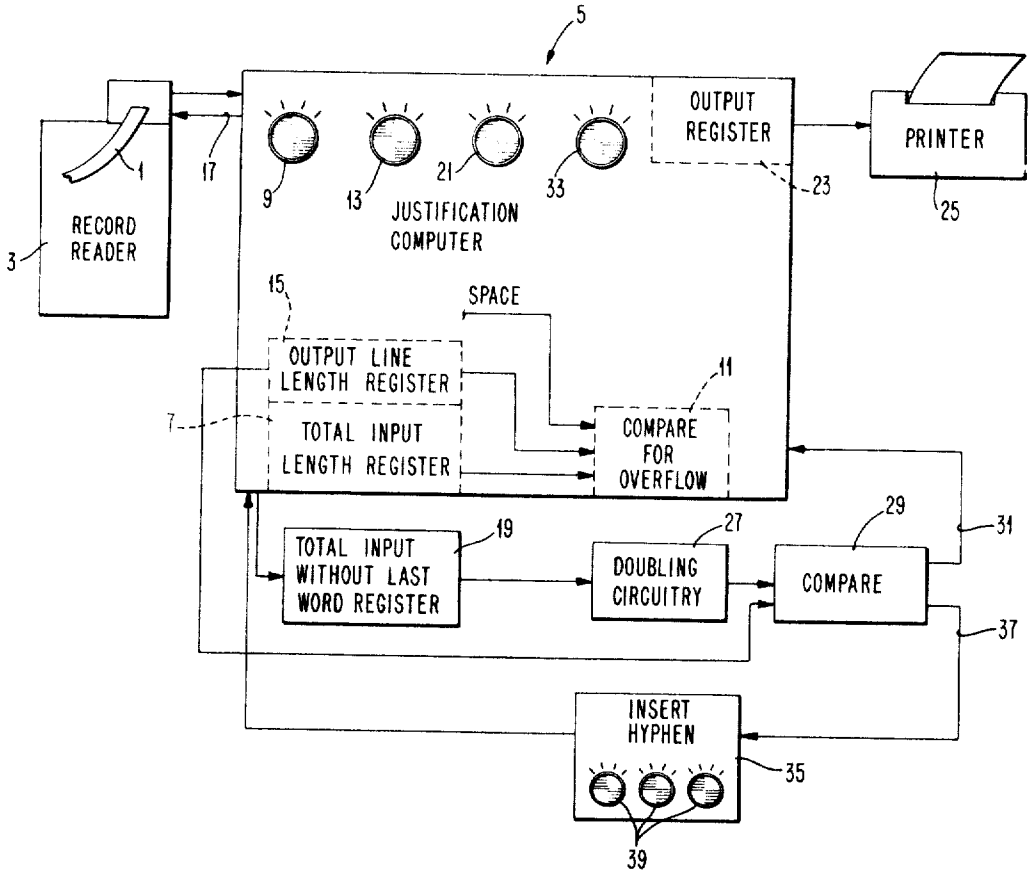

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EFFICIENT JUSTIFICATION QUALITY CONTROL

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ABSTRACT OF THE DISCLOSURE

In the preferred embodiment described, a designated register is provided to store in numeric notation the minimum length of characters in a line to be justified existing prior to the last word which would cause the total length to exceed the length of the output line. This value is doubled by adding it to itself once and compared by a subtraction operation with the length of the output line. If the doubled value is greater than or equal to the length of the output line, the characters prior to the last word are printed out with inter-word spacing as desired and with enough inter-character spacing to justify the line. If the doubled value is less than the length of the output line, the characters are not printed until a hyphen is inserted in the last word, and the portion including and before the hyphen is included in the output line. This provides an automatic and efficient check on the quality of the justified text while eliminating special controls to limit inter-character spacing amounts.

BACKGROUND

Justification is the spacing of text so that the printed characters extend to both the left and right margins. The prior art knows many techniques to justify text from records. In this regard many data processing techniques are readily adaptable by those skilled in the art.

It is often desirable that the justification system use information received from records carrying "raw" data, that is, data in which line endings are not specified on the data carried by the record. Preparation of the records by recording on paper tape, magnetic tape, or similar records can then be done at the highest possible speed and with the use of the least possible special skills because no thought need be given to selecting the location of line endings or of hyphens. Furthermore, text in raw form, properly processed, can be ultimately recorded at output line widths not originally known by the operator who prepared the record, and it can be ultimately recorded at more than one line width. To process raw data many data processing techniques are also readily adaptable by those skilled in the art.

Thus, the justification of raw data is readily achieved by the art, and many variations are available for use to control the quality of the text ultimately produced at the output. This invention concerns efficient and economical means to control the level of quality of the output text.

Level of quality depends primarily upon the limitation of the maximums of various spacings in the output text while still maintaining proper grammar, spelling, and justification. Prescribed limitations on spacing vary according to the judgment applied in view of the particular aesthetics desired for the final output, to the economic facts, and to similar factors. For example, it is generally true that greater variation between maximum and minimum interword spacing is considered acceptable in the printing of a newspaper than in the printing of a quality book memorializing a person of worth.

Much is available in the data processing art to achieve desired levels of quality. It is available to provide a number of data processing routines which would check justification results computed to assure that pre-established maximum inter-word and inter-character spacing is not exceeded. Should the checks show that a maximum is exceeded, other routines could be provided to assure hyphenation and use of a subsequent word in text or to otherwise achieve the output quality level desired. The characteristics of final copy have been controlled in at least one prior art system by an automatic response to a pre-established minimum difference between the length of a line of text received prior to the last word of text which would bring the length of the prior text received over the length of a line. When this difference is at least a pre-established amount, hyphenation of the next word of text is automatically conducted, and the hyphen and portion of the word before the hyphen are used as part of the preceding line of text. As will be clear, however, that system of hyphenation is more complicated than the pertinent aspects of the invention here described and it tends to favor hyphenation whereas the invention here described does not. It is also known to perform the necessary check prior to interword justification by multiplying the number of interword spaces by a pre-established factor and then comparing this result with the amount of space to be filled; but this check in no way takes into account the various sizes of different symbols and other factors having to do with inter-character justification.

In accordance with the invention here described performance of many of the data processing manipulations found in the various prior art is avoided. This achieves a great savings in machine hardware, and, just as importantly, in the processing time consumed. Also, means to insert or produce in the mechanism the maximum inter-character spacing allowable in general or in a number of special cases need not be provided. This is a further saving in hardware and simplifies human factors in the operation of the machine. It is believed that no precise limit on inter-character spacing is necessarily desirable so long as the quality control in accordance with this invention is used because inter-character spacing, as a practical matter, is a last resort attempt to justify such that relatively large inter-character spacing is at that point inherently acceptable.

A salient feature in accordance with this invention is the elimination of the need to structure the parts to consider special cases. In general, when special cases must be considered, they must be considered in every inter-character operation which initially appears to call for hyphenation in order to achieve adequate justification. Two common special cases, especially in newspaper composing operations, are the one word sentence and the two word sentence. In both cases adequate quality level usually demands that the lines be justified by inter-character spacing even though the inter-character spacing is greater than that considered permissible in the usual line. Another special case, desirable in many systems, is to automatically determine if an input word was received after the last one considered for justification. Such a word must have been received, of course, if the mechanisms are to achieve justification by hyphenation of that word.

It is an object of this invention to provide an efficient and economical quality level control for justification.

It is a more specific object of this invention to provide means to properly justify text from an input of "raw" text.

It is a more specific object of this invention to provide justifying means requiring less structure and use of structure.

It is another, more specific object of this invention to provide justifying means in which no specific control of inter-character spacing need be entered by the operator of the justifying means.

In accordance with the broadest aspects of this invention a gross check is made which compares available data concerning the text received with the output length requirements. This makes possible an efficient and quick determination that inter-character spacing subsequently computed will be within acceptable limits. Usually considerable data concerning the content of a line of text received can be compiled while the line is being received since the record reader or other source of text is quite slow compared to the speed of the devices used to justify. In accordance with this invention the data operated upon and the computation engaged in need not generally produce an exact determination of intercharacter size, but instead the selections are made to yield accuracy within gross limits and to be relatively efficient and fast. Since the comparisons made do not have critical limits, relatively small values could be added or subtracted to the data and factors used without impairing the basic control of quality level obtained, but this is generally unnecessary and would increase the time and structure required.

Although the more preferred aspects described below are based upon a scheme which uses the exact length of text in a line received, the number of characters in a line received will generally be a readily available figure. This number could be readily multiplied, such as by adding it itself or by a three column shift operation on a binary number, to achieve a multiplication by some factor such as eight, and the multiplied result compared with the output line length. Similarly, the difference between the length of received text and the output line length is generally a factor already computed and could be used instead of the output line length. Inter-character spacing computation would be conducted only when that multiplied number is shown to be at least a certain size relative to the output line length or the related factor. This test is not precisely related to the exact inter-character spacing, since the width of each character in the received line is not precisely considered. However the results are within limits which would adequately control the quality of final copy.

In accordance with the more preferred aspects of this invention, a computation is made which requires for the multiplication step only the single addition of one number to itself. Thus, the minimum width of a line of text entered into the justification means is accumulated up to a grammatically acceptable line ending. Prior to production of the output on the basis of the text received, the value of that length is doubled by adding it to itself once and then compared with a pre-established value equal to the the total length to be occupied by the output line. If the comparison shows the minimum length to be about half as large as the output line length, then justification of that line of text up to the grammatically acceptable line ending is permitted. Inter-character spacing is not limited and normally may be as great as the justification computations require, although some non-essential structural limitation in the machine may prevent exceptionally large inter-character spacing. If comparison shows the minimum width to be too small, part of the next word of text is used with a hyphen inserted in that word as required. The output recorded in justified form may be printed for immediate use or stored as codes on a paper tape or similar memory.

In accordance with this invention hyphenation in output text is avoided to a very great extent. On the other hand, however, in a particular composition the quality level desired and other factors may be such that inter-character spacing is considered less desirable than hyphenation. Machines containing this invention will therefore often also contain the capability of selecting another mode of operation in which inter-character spacing is avoided or greatly limited.

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 drawing.

The drawing is a symbolical and illustrative diagram of the preferred system in accordance with this invention.

In the drawing, conventional symbols and labels illustrate the structures employed. Implementation of the entire system may take a number of forms, all well within the skill of the justification or data processing art. The registers and comparison means used may be any conventional circuitry, but, as more fully detailed below, definite advantages are obtained by accumulation in numeric notation and comparison by means of a subtraction operation.

The record carrying raw data may be prepared as a sequence of codes on a magnetic tape recorded by special typewriters available for this purpose or the record may be prepared by any suitable means. The record tape **1** is then read by reader **3** under the control of justification computer **5**. Reader **3** preferably takes the form described in U.S. patent application Ser. No. 579,355, filed Sept. 14, 1966, entitled Record Reader With Controls, by Parker R. Blevins, Roderick S. Heard, and Louis M. Hornung, and assigned to the assignee of the present invention. The justification computer **5** accumulates the weighted width values of each received character and, when a line ending condition is detected as will be described below, computes the inter-word and inter-character spacing necessary to produce a justified line of data characters. The justification computer **5** can take the form of a general purpose computer programmed in a well known manner to calculate the necessary spacing or the form of a special typography computer operable in a well known manner to accept unjustified tapes and generate justified tape. When the latter type of computer is utilized, a control counter such as that described in U.S. patent application Ser. No. 578,791, filed Sept. 12, 1966, entitled Electronic Counter, by Louis M. Hornung, and assigned to the assignee of the present invention may be utilized in a well known manner to control the sequencing of the operations performed by the justification computer and the operations performed by the remaining units of FIGURE 1. When thus utilized, the counter functions as a "state counter" which is advanced or permuted to a different unique state upon the completion of each operation. The counter thereafter controls the operations to be performed. The utilization of a "state counter" to control the sequencing of computational operations is well known in the art and need not be described in detail, it being kept in mind that in the following description each pulse or signal which is supplied upon the termination of an operation causes the state counter to change to a state that will initiate the next operation described.

The minimum length of each character of text supplied to the justification computer **5** is simply the horizontal width actually to be occupied to display that character when that character is ultimately displayed. In the preferred embodiment, in the case of symbols as distinguished from spaces, this varies between three units for a period and other smallest symbols to nine units for the letter "M" and other largest symbols. As each character is received from magnetic tape **1**, the minimum value of it is automatically found by justification computer **5** in a well known manner and accumulated in total input length register **7**. The accumulator register **7** can be of any of the types well known in the data processing arts, examples of which may be found on pages 101 through 112 of "Arithmetic Operations and Digital Computers" by R. K. Richards, copyright 1955 by D. Van Nostrand Company, Inc. A code from tape **1** indicative of a normal space, as distinguished from a printed symbol or a function other than spacing the usual amount, is automatically interpreted as being indicative of the end of a word and also as normally constituting an inter-word space. Associated with justification computer **5** is an input key **9** operative to pre-establish in computer **5** the minimum inter-word

space desired in a given justification operation. Depending upon the characteristics of the display desired, input key **9** may be manually adjusted to, for example, pre-establish a value of four units for one justification operation and to pre-establish a value of five units for justification of a different manuscript. As a normal space code is received, total input line length register **7** is increased by the pre-established minimum length of the inter-word spacing.

In this manner register **7** accumulates the total minimum length of text received. This continues as codes are received, but with each normal space code received a comparison is made in compare for overflow circuit **11**. The output line length, which is the total or full length to be occupied by a line of text, has been pre-established by a manual operation of a key **13** (it could be relatively small, as for a newspaper, or wider, as desired, for a book). This value for the output line length is stored in register **15**. This register can be of the form well known in the data processing art consisting of a plurality of binary storage elements adapted to store the binary representations of the value of the output line length. Thus, with each normal space code, the total minimum input length and the output line length are compared in circuit **11**. When an overflow is found, that is, when the minimum length of text accumulated including the last normal space code exceeds the output line length, circuit **11** responds such that justification computer **5** pulses reader **3** by line **17** so that further reading of text by reader **3** is temporarily halted. The compare circuit **11** can be a conventional arithmetic circuit similar to that described hereinafter with respect to the compare circuit **29**.

Another register pertinent to the instant invention, register **19**, computes the total input length without the last word. This register can also be a conventional data processing register consisting of a plurality of binary storage elements adapted to store a representation of a value. The values accumulated are identical as above described for total input length register **7**, but values for text including and immediately following the last normal space code are not accumulated into this register until the result from compare for overflow circuit **11** indicates that no overflow was caused by the values attributed to the last word received. The total input without last word register **19** can be loaded with the values stored in the total input length register **7** when no overflow occurs. Thus, when an overflow is sensed, register **19** contains the minimum length of all full words received from tape **1** for a given line, up to a space, which defines, of course, a grammatically proper line ending. (When overflow just occurs because of the spacing attributable to the last normal space code, this is processed as a special case. The instant invention then is unnecessary for use with the line involved since the output line will inherently be justified to one of good quality.)

The textual content of information received by justification computer **5** is stored in justification computer **5**. When an overflowed line as above described is received, justification computer **5** then automatically calculates the inter-word spacing necessary to justify the line without the last word. Since the line justified ends immediately before a space, it necessarily has a grammatically acceptable line ending. The justification may be implemented by straight-forward division by electronic data processing means of the space to be filled by the number of inter-word spaces. Also by electronic data processing, the inter-word spacing computed is compared with a pre-establishes first preferred maximum inter-word value inserted manually by a key **21**. This value will be one selected in accordance with the quality level desired, and it may be, for example, eleven units for a newspaper application or seven units in a book application. If the inter-word spacing computed is equal to or less than the pre-established maximum value, then the textual data is simply transferred to output register **23** with codes indicative of the computed spacing inserted between the groups of codes making up words. The output register **23** is a conventional data processing register consisting of a plurality of storage positions each adapted to store a data character representation or a space code representation. In this manner, an entire line of data characters can be stored in the output register **23**. Print out in this regard from justification computer **5** to a printer **25** is preferably as described in U.S. patent application Ser. No. 580,275, filed Sept. 19, 1966 entitled Variable Spacebar Mechanism for Automatically Operated Proportional Escapement Printer, by Wiliam H. Castle, John E. Jones, and Robert A. Rahenkamp, and assigned to the assignee of the present invention.

It is desirable to first attempt to justify within the first preferred inter-word spacing limits permitted because this justification is usually successful. Thus, a number of processing steps and the associated time involved is saved in the frequent instances when the inter-word computations result in a completely justified line. Many times, however, the inter-word spacing computed will be too large. In this event, justification computer **5** will automatically pulse doubling circuitry **27**. Doubling circuitry **27** accepts from register **19** the total input length without the last word and doubles that value. Then circuitry **29** compares the output line length from register **15** with the value from doubler **27**. If circuitry **29** responds to represent that the doubled value is equal to or greater than the output line length, then justification computer **5** is pulsed by line **31** accordingly. In this event justification computer **5** automatically calculates the output by straightforward division of the number of characters less one into the space to be filled, with the assumption of an inter-word space width equal to a pre-established maximum interword spacing, which preferably is a somewhat larger inter-word spacing than the first preferred maximum interword spacing used in the first justification computation. This larger spacing value, denominated maximum quad spacing, is manually inserted by the machine operator with a value as desired by use of key **33** prior to use of the machine for composition of a particular piece.

In the manner described above, codes representative of the next, within this case codes inserted between character codes, each representative of the inter-character spacing computed, are transferred to output register **23** and ultimately to printer **25**. There is no limitation placed on the amount of inter-character spacing which may be outputted when computation of inter-character spacing is conducted as just described. (The inter-character spacing, of course, to the extent inserted is distributed substantially evenly between the various symbols and spaces in the output line. The preferred printer is a unit spacing device, so completely even distribution is not always possible and in some lines some of the inter-character spaces are therefore made one unit greater than others. In some lines the amount of inter-character spacing will be relatively small, and then a unit of spacing is inserted between the first characters until all of the inter-character spacing is inserted.) The previous check to assure that the doubled value is at least a certain relative magnitude is adequate to assure a good quality level.

Conversely, if circuitry **29** responds to represent that the doubled value is less than the length of the output line, then the insert hyphen structures **35** are pulsed by line **37**.

In the preferred embodiment the hyphen is inserted manually, that is, the last word received by justification computer **5** is displayed and the machine operator mentally decides where that last word should be hyphenated. Then the operator manually keys that information into the insert hyphen structures **35** using keys **39** to thereby select the position for hyphenation.

After that hyphenation selection signal from structures **35**, the operation is once again automatic in the manner generally as described above. Justification computer **5** cal-

culates maximum inter-word spacing based upon the inputted text including the part of the last word before the hyphen point and including a hyphen as the last character in the line. It is preferred at every point in the processing after the first interword calculation to automatically use the maximum quad spacing, which is somewhat larger, as the maximum inter-word spacing. If in this subsequent computation of inter-word spacing the maximum quad spacing is found not to be exceeded, then the line of text is outputted to register **23** and displayed by printer **25** in the manner previously described. If the maximum quad spacing is exceeded, then, without further check to determine if inter-character justification is desirable, justification computer **5** computes the inter-character spacing to be inserted as the space between words, and the text with that inter-character and the maximum inter-word spacing inserted is outputted to register **23** and displayed by printer **25**. There is then no limitation on the inter-character spacing which may be computed and outputted.

After one line of text has been transferred to output register **23**, reader **3** is pulsed once again on line **17**, and the steps and functions described above are repeated to thereby process the next line of text. Any part of the last word received which was not outputted as part of the previous line is, of course, inserted as the first part of the next line.

The amount of multiplication made in accordance with this invention of the minimum length of a line of text without the last word is fundamentally a matter of choice. A multiplication by a somewhat smaller value than two, such as a multiplication by 1.8, would achieve a higher quality level (but not necessarily the desired quality level) in the sense that smaller inter-character spacing would generally be then produced. The multiplication by two, however, is entirely satisfactory and provides good structural efficiencies. Thus, the value in register **19** is multiplied by two by simply adding that value to itself once in a conventional arithmetic circuit. (It is entirely clear, of course, that the addition by two at this particular point is merely a matter of convenience in this particular arrangement. In the previous inter-word justification computation the length of text without the last word was subtracted from the output line length. During inter-character justification one subtraction of the text length from that result would conveniently implement the desired subtraction of twice the text length from the output line length, which is a closely similar alternative to the preferred arrangement.)

In the preferred arrangement comparison circuitry **29** is implemented by simply subtracting in a conventional arithmetic circuit the output line length from the doubled value. If a highest order borrow is not produced in the subtraction, the signal described on line **31** is produced. If a highest order borrow is produced, the signal described on line **37** is produced. (A one unit difference is values at which the result of the comparison by subtraction would change would be created if the doubled value were subtracted from the line length. The high order borrow would then be used with reversed significance. This simply represents a minor change in result which is readily available if desired.)

Simplicity and reduced structure are thus obtained while the output quality level is assured. The machine operator need not make reference to a maximum inter-character input, whereas otherwise there is a distinct psychological tendency for the machine operator to insert a small inter-character value even when machine operation avoiding hyphenation is desired. The structures in accordance with the invention are economical and fast in implementation. In particular, computing the multiple and making the comparison are short, uncomplicated steps which occur before the inter-character spacing is computed. In fact, the computations of this preferred embodiment require roughly one-eighth of the number of steps and yield a significant reduction in structural requirements as compared to computations in the same machine as described when more direct intercharacter spacing checks were made along with special case checks such as for one and two word lines and for the receipt of a word for use in hyphenation. Additionally, final control is placed with the operator since the operator may key in a signal from insert hyphen structures **35** which operates to refuse a hyphen by causing the machine to justify at maximum quad and with substantially evenly distributed spacing inter-character as needed.

It is, of course, common, especially in newspaper operations, to indent certain lines a specified amount. This is true also in inserting paragraph indentations. This invention is used as above described during indent operations. Right side of page indent operations are simply handled as shorter output lines. Left side of page indent operations are inserted as space codes at the beginning of a line of text. Inter-character spacing is not permitted between those space codes, of course, but they are accumulated and the result processed in accordance with this invention as part of the minimum width of a line of text received. It would be possible to treat a left indent operation as a shorter line, but this is demanding in structure and processing time, and is therefore not preferred since the results obtained by treating left indent as spacing in a line of text received are satisfactory.

The above operations are preferred for most compositions since hyphenation in the output text is almost completely avoided. However, at times a tighter text, even at the cost of hyphenation, will be desired. Therefore, provision is made for the machine operator to bypass the invention here described for another mode of operation. In that mode of operation, unsuccessful inter-word justification automatically causes the insert hyphen structures **35** to become operative. The machine operator then inserts hyphens and similarly assumes control of the output before any inter-character spacing is permitted.

The improvements here described are therefore suitable for incorporation in a wide range of different justification systems. Since the check made is fundamentally one of relative proportions, the same structures will respond automatically to different values inserted for the total length to be occupied by a line of text. Thus, key or other means are provided to readily insert different output line lengths in register **15** depending on the manuscript to be composed. No other changes are required and the response of the system in accordance with these improvements is as described.

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 the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

I claim:

1. A justification system including means to receive unjustified text symbols including character symbols and inter-word space symbols, means to accumulate data related to the length to be occupied by the text symbols in a line of text symbols received which will occupy a minimum length which is not greater than the total length to be occupied by a line of justified text symbols, the text symbols received having a grammatically acceptable line ending, actuable justification computer means for calculating the inter-word and inter-character spacing of the line of text symbols received utilizing up to a preset maximum inter-word spacing to achieve a justified line of text characters, and means to record the received text symbols in the justified form computed wherein the improvement comprises:

comparison means structured to receive two numeric values and operate upon said two numeric values once to produce essentially only a first condition and a second condition, said first condition being produced when one of said two numeric values is at least

a pre-established proportion of the other of said numeric values and the second condition being produced when said one numeric value is less than said pre-established proportion of said other numeric value,

means to transmit to said comparison means as said one numeric value a first factor proportion to the value represented by the data accumulated and as said other numeric value a second factor proportional to the total line lentgh of the justified text, and

means responsive to said first condition for actuating the justification computer means to calculate the inter-word and inter-character spacing utilizing the preset maximum inter-word spacing without essential limitation as to the size of inter-character spacing between characters in the line of justified text characters.

2. The system as in claim 1 also including:

normally inoperative means to insert hyphens selectively into received text, and

means responsive to said second condition to cause said means to insert hyphens to become operative.

3. The system as in claim 1 structured so that said comparison means is not operated until after said justification computer means has established that successful justification using only a pre-established maximum inter-word spacing is not available.

4. The system as in claim 1 in which:

said comparison means operates by subtracting one of said two numeric values from the other only once and said first condition and said second condition are established by whether a highest order borrow is produced.

5. The system as in claim 1 including means to effectively multiply by performing at least one arithmetic operation which effectively adds the value represented by said accumulated data to itself an integral number of times, the result of said means to effectively multiply establishing said first factor.

6. The system as in claim 5 structured so that at least said means to compare does not become completely operative until after said justification computer means has established that successful justification using only a pre-established maximum inter-word spacing is not available.

7. A justification system with means to receive unjustified text, justification computer means to calculate the spacing to achieve justified lines comprising different symbols which occupy different widths, normally inoperative means to insert hyphens selectively into received text, and means to record said text in the justified form computed wherein the improvement comprises:

means to accumulate data related at least generally to the minimum length to be occupied by the text in a line of text received prior to the last word of text which would bring the minimum length of text received over the total length to be occupied by a line of text,

means to compare the value represented by said data accumulated with said total lentgh to be occupied by a line of text, said means to compare including means to receive a first value and a second value and means to normally produce a first result from each comparison in which said first value is significantly less than said second value and to normally produce a second result from each comparison in which said second value is significantly more than said first value, said means to compare receiving as said first value a value established by the value represented by said data accumulated and receiving as said second value a value established by said total length to be occupied by a line of text, said first value and said second value being defined so that said first result is produced only when the minimum length to be occupied by said line of text received is in the order of magnitude of less than one-half of said total length to be occupied by a line of text, and

means responsive to said first result to cause said means to insert hyphens to become operative.

8. The system as in claim 7 structured so that at least said means to compare does not become completely operative until after said justification computer means has established that successful justification using only a pre-established inter-word spacing is not available.

9. The system as in claim 7 including means to effectively multiply by performing at least one arithmetic operation which effectively adds at least the approximate value represented by said accumulated data to itself an integral number of times, the result of said means to effectively multiply at least partially establishing at least one of said first value and said second value.

10. The system as in claim 9 structured so that at least said means to compare does not become completely operative until after said justification computer means has established that successful justification using only a pre-established maximum inter-word spacing is not available.

11. The system as in claim 7 in which:

said means to accumulate accumulates data related at least approximately to the minimum length to be occupied by said line of text received.

12. The system as in claim 11 structured so that at least said means to compare does not become completely operative until after said justification computer means has established that successful justification using only a pre-established maximum inter-word spacing is not available.

13. The system as in claim 12 including,

means to effectively multiply by two by performing an arithmetic operation which effectively adds to itself only once at least the approximate value represented by said data accumulated, the result of said means to effectively multiply at least partially establishing at least one of said first value and said second value.

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PAUL J. HENON, Primary Examiner

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