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⑤④ **Method for adaptively using a print ribbon in an impact printer.**

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US-A-3 346 090

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Description

The invention relates to a method for adaptively using a print ribbon in an impact printer such as a typewriter or dot matrix printer, for example.

Generally, in impact printers two types of print ribbon are used. The first may be called a single-use ribbon, where the colouring material, such as carbon, at the impact location is completely transferred to the record carrier, thus leaving a non-colouring area on the ribbon substrate, so that after one complete pass of its entire length for successive printing the ribbon has to be discarded, save any provisions for repleting. The second type of ribbon, in contrast, may usually be passed back and forth several times in front of the printing station since after each impact and ensuing removal of dye from the impact location, sufficient time is provided as the ribbon is further advanced, and later reversed, for the dyestuff to "bleed" into depleted areas from the neighbourhood so as to maintain a reasonable though continuously degrading print quality over several reversals of the transport direction of the ribbon. These print ribbons as well as their transport mechanisms are so commonplace that it appears unnecessary to list references for their description.

As was pointed out before, with the second type of ribbon one has to accept that the print quality gradually decreases until it reaches a minimum tolerance level at which the ribbon has to be replaced. This is very simple in the case of a single-colour ribbon but complex if a multi-colour ribbon is employed because not all of the colours will be used with the same frequency. It may happen, therefore, that red, for example, was frequently used for printing pictures and is accordingly rather depleted after some time, while yellow was rarely used and thus stays fresh.

Another point to consider is the smudging of the ribbon through take-up thereby of dust and dirt which may cause ribbon areas unwilling to print although enough colourant is available, or which leads to undesirable obscuring or changing of colours.

CH—A—474 757 describes method and device for measuring the density of the printing ink in a multi-colour printer. A current sample of the printing ink of each colour is compared with a standard of the respective colour in that light is shone through the inks under investigation and directed onto photosensitive means for electronic comparison.

That same CH—A—474 757 refers to conventional apparatus for determining the density of printing colours employing complementary colour filters.

This state of the art does not address the economics of print ribbon use, in particular no provisions have been proposed to permit an appropriately fresh portion of the print ribbon to be made available at the printing station in case a high-quality printing job is to be performed. The present invention aims at proposing a method for

adaptively using the print ribbon, i.e. provide undepleted ribbon if high quality printing is desired but leave the ribbon just as it happens to be if no special quality requirements have been signalled.

The method in accordance with the present invention for adaptively using a print ribbon, be it in single-colour or multi-colour impact printers is characterized by transporting by small increments in forward and reverse directions, during printing operation, one subsection of predetermined length of the ribbon, continuously monitoring the condition of the printing colour or colours in said one subsection, until the condition of said colour or of any one of the colours in said one subsection has reached a predetermined lower tolerance level, and then advancing the ribbon so as now to expose at the printing station the subsequent, fresh subsection of the ribbon, regardless of the condition of the possibly remaining colours in said one subsection, for repeating the procedure until the entire ribbon is used up.

With this method it will be possible to immediately advance to a fresh ribbon subsection through manual intervention by the operator in case a printing job is signalled to required high-quality printing.

Details of the method in accordance with this invention will now be described with reference to the attached drawings in which:

Fig. 1 shows the essential components of a wire matrix printer;

Fig. 2 shows a multi-colour ribbon with its spools and lift fork;

Figs. 3 and 4 depict the degradation of the ribbon quality over time;

Fig. 5 schematically shows an optical ribbon quality monitoring device;

Fig. 6 refers to minimum and typical lengths of ribbon subsections;

Fig. 7 represents the interconnections between the components of a ribbon quality monitor;

Figs. 8 and 9 show flow diagrams for the interrupt and ribbon advance routines, respectively;

Fig. 10 is a schematical diagram of the counter circuitry of Fig. 7.

Besides typewriters which account for the greater part of all impact printers in use today, there is an increasing number of dot-matrix impact printers which serve as output printers for digital computers, in particular in applications where alphanumeric characters and pictures are to be printed. In most previous cases impact printers have used single-colour ribbons but as the art of colour-image reproduction advances, the multi-colour dot-matrix impact printer is gaining importance for producing sharp, accurate colour images for graphics applications.

While the method of the present invention is considered applicable to both, single-colour and multi-colour impact printers, the explanation of the invention will be made by way of example with reference to a multi-colour dot-matrix printer

the functioning of which will now briefly be reviewed.

Referring to Fig. 1, the printer 1 comprises a platen 2 which carries a record carrier such as a sheet of paper 3. Platen 2 is supported in frames 4, 5 and indexed via belt 6 and pulleys 7 and 8 by a stepper motor 9. Slidingly supported on rods 10 and 11 is a print head 12 which may be escaped along the print line by a belt 13 slung around drums 14 and 15 and driven by a stepper motor 16.

Print head 12 contains, e.g. seven wires (not shown) arranged at equal mutual distances in a column, the tips of the wires directed against platen 2 and their ends connected to electromagnets which may be selectively energized via a flexible cable 17 connected to appropriate control apparatus as is known to those skilled in the art. Printing of alphanumeric characters and symbols is through composition of single dots in a 7×5 matrix arrangement, i.e. after the parallel energizing of the appropriate number of wires the print head has to be advanced by one fifth or less of a character width whereupon the selective energization for the then actual print position will be made, and so forth until a character is completed and an intercharacter escapement is accomplished.

The wires impact actually against a print ribbon 18 arranged between platen 2 and the print head 12 and extending between two spools 19 and 20. The latter are supported by means (not shown) for movement in both directions under control from a control unit to be described below. Print ribbon 18 (Fig. 2) has four parallel colour bands 21 through 24, for example, with yellow (21), magenta (22), cyan (23) and black (24) inks, respectively. These inks permit printing in a total of seven different colours by superposition in accordance with the subtractive primary colour system which is, for example, explained in EP—A—Nr. 0 011 722. Print ribbon 18 may alternatively be dedicated to a different system of colours such as the one disclosed in CH—A—610.825 which prefers golden yellow, carmine, violet and turquoise. Still another system might comprise the positive primary colours red, yellow, blue and black, the black always being used to enhance contrast.

The colour band to be presented at the print station for printing is selected by a print control unit which either controls the lifting of a conventional ribbon fork 25 or of said ribbon spools 19 and 20. The differently coloured inks are composed such that every two inks impregnated on adjacent bands are mutually repelling so that their mixing (bleeding) is prevented and no degradation of one ink by its neighbour can occur.

Printers of the type described above presently can perform up to a speed of 5000 imprints per second. The limitation in speed is mainly dictated by the mechanical parts which must be moved, viz. the print wires and their associated electromagnets. With a further reduction of mass of the wire/electromagnet assemblies and with

improvements in the materials used in the print head, still higher speed will certainly be possible soon.

Attainable printing speed and recent advances in LSI technology bring the introduction of image processing systems on the basis of dot-matrix impact printers closer to reality. However, the high density of multi-coloured dots necessary for accurate image printing accents the need for precise, clear, clean dots from a print head/ribbon assembly. As a ribbon begins to age, it commences to produce faded, blurred dots which make an exact image reproduction impossible.

In the printers of the prior art, the entire ribbon is treated as one unit assumed to have the uniform deterioration characteristics as shown in Fig. 3. When the ribbon is new, its quality is, of course, very high, but with use the quality decreases until a lower quality threshold is reached at which replacement of the ribbon is required. Uniformity of wearing is achieved by escaping the ribbon by a small increment after each printing impact until the entire supply of new ribbon is used up and then reversing the direction of transportation several times until said lower quality threshold is reached.

There are several problems with this method which make it unsuitable for high-resolution colour printing. The primary problem is that multi-colour ribbons cannot be made to wear uniformly across all colours. Invariably, part of the ribbon will become smudged or faded, or one of the lighter colours collects black or just dirt. Accordingly, one or more of the colour bands may have reached their predetermined lower quality level while others have not, yet the ribbon continues to be used since part of it is still usable. Obviously, images printed with a ribbon in this state will have blurred, faded or otherwise corrupted sections.

Another problem with prior art printers is that there is no reliable method for monitoring ribbon quality. The surest sign that a ribbon needs replacing is a poor colour print. And it is indeed difficult to set a lower quality threshold since printing jobs may have different quality requirements. If a job requires high quality, with prior art printers the operator is forced to replace the ribbon although it may not yet be worn down.

The method of the present invention remedies these problems by partitioning the entire ribbon into several subsections of essentially equal length and employing those subsections for printing sequentially until each one reaches its individual lower quality level and then switching to a fresh subsection. Fig. 4 shows this for a colour ribbon partitioned into six subsections $S_1 \dots S_6$, with the life of the subsections varying with the parameters of the colour images printed, such as frequency of colour changes, colour dot density, printer speed, degree of resolution, etc. The comparatively fast deterioration of subsections S_2 and S_5 may be due to dark colour overprint causing a lighter colour band to fade or a high frequency of colour variation causing

streaks on the ribbon's colour bands. Because in accordance with this method one subsection is completely exhausted before the printer switches to the next, the faster deterioration of subsections S_2 and S_5 in the example of Fig. 4 is not allowed to harm the overall picture quality.

To advantageously employ the inventive method, it will be necessary to continuously monitor the quality of the ribbon subsection currently in use. The following three schemes are contemplated to do this:

The first monitoring scheme employs discrete counters to count the number of times the individual colour bands in a ribbon subsection are struck by the wires of the print head to produce a dot. Each colour is assigned its own empirically determined maximum count. When the number of dots produced from a particular colour exceeds the maximum count for that colour, the monitor will issue a signal causing the ribbon transport mechanism to advance the ribbon to its next subsection. In presetting the maximum number of counts, the quality requirements of the printing job can be balanced against ribbon longevity.

The second monitoring scheme as shown in Fig. 5 is basically optical and comprises a light source 26 and a photo-detector 27. The idea here is that a streaked, smudged or faded ribbon can be detected by the intensity of light it emits. The photo-detector is mounted adjacent print head 12, and as the latter is escaped, the detector scans ribbon 18. Light from source 26 passes through a short length of each colour band of ribbon 18 to a bank of optical filters 28 through 31. Each filter suppresses every colour except the one of the colour band directly in front of it. For example, light shone through the magenta band 22 is passed through corresponding filter 29. The filtered light is then passed to a string of photo-sensitive elements 32 through 35 which convert the intensity of the colour received from their associated filter 28 through 31 to electrical signals which they feed to individually connected integrators 36 through 39. Each integrator adds the signals received over time to the previous output of the respective photosensitive element 32 through 35 and supplies its output signal to one of comparators 40 through 43 which have one of their inputs commonly connected to a threshold voltage. Separate adjustment facilities may be provided at the comparators so as to permit the threshold for each colour to be preset individually.

If after a specified time, which may, e.g. correspond to one sweep, the voltage output from one integrator is below the threshold for the colour concerned, then detector 27 signals via OR gate 44 that one of the colour bands in the current subsection is corrupted. Ribbon 18 is then advanced to the next, fresh subsection.

The third scheme simply involves a manual advance option. When, for any reason, the operator desires to proceed to a fresh subsection of ribbon 18, e.g. for a printing job requiring high quality, this option may be used. The ribbon then

advances to the next subsection regardless of the state of the current subsection.

The length of the ribbon subsections can be set by the operator prior to printing. The minimum practicable length corresponds to the distance the print head 12 can travel across platen 2 between the left and right stops 45, 46 (Fig. 1 & 6). Typically, the length ΔL of a subsection should extend on both sides beyond said travel distance. In the latter case, to ensure uniform aging/wearing of the entire subsection, ribbon 18 has to be advanced and reversed by a tiny fraction Δx of the subsection length ΔL for every couple of print head carrier returns.

Implementation of the method so far described is best done on a microprocessor-based system having the necessary degree of functionality. A block diagram for such a system is shown in Fig. 7. For the purpose of the following description, the operation of the system is divided into three phases: power-up, normal operation, and power-down.

During the power-up cycle, microprocessor 47 runs through some check-out routines and then reads the operating parameters pertaining to the previous operation out of a non-volatile memory 48 and into the appropriate units, such as a random access memory 49. Into specific areas of memory 49 are read the maximum count for the wire impacts on the ribbon for each colour band 22...25, the length ΔL for the ribbon subsections, the current count for Δx , and the maximum count for Δx . The previous values off the counters (which were saved in memory 48) are rounded off, e.g. to the nearest 10^{20} and read back into the counters. When this is complete, microprocessor 47 commences normal operation by causing the printer to print.

During printing operation, the number of impacts the print wires perform on ribbon 18 is counted separately for each colour. Simultaneously, photo-detector 27 is swept across ribbon 18 to discover any faded or smeared colour bands. When the impact count for any colour exceeds the preset value or a corrupted colour band is found, or if the manual Ribbon Advance button 50, Fig. 7, is pushed, a flip-flop 51 is set to be read later by processor 47. When a return of the print head carrier is signalled by printer 1, an interrupt signal is generated, and microprocessor 47 enters an interrupt routine (Fig. 8). In block 52 first the RESET button 53 is checked. Since the mechanism is preferably designed such that hitting RESET button 53 does not have any effect while printing is in progress, reset flipflop 51 is assumed to be reset. Therefore, the operation proceeds to block 54 decrementing the current carrier count which is representative of the number of carrier returns performed since the last time the ribbon was advanced. When the current carrier count reaches zero (block 55), said count is reloaded from memory 48 and the ribbon is advanced by Δx (fig. 9).

When microprocessor 47 determines that ribbon 18 should be advanced, it checks first on

the direction of advancement, i.e. forward, backward or not at all, as would be the case if the length ΔL of a ribbon subsection was chosen to be equal to the distance of carrier travel. The processor will look at the number of times the ribbon was previously advanced by Δx by asking whether the current Δx count has reached zero (block 56). If the answer is NO, i.e. the ribbon has not reached the end of the current subsection, the processor reads the direction flag stored in memory 48 (block 57). If the answer to the question of block 56 is YES, the processor asks the direction flag at which end of the subsection the ribbon is. If the ribbon is at the left end of the subsection, (block 58) it just reverses direction and begins to progress to the right end of the subsection. If the ribbon is at the right end of the subsection, the processor checks (block 60) the status of flipflop 51 (which may be set by the counters 59, the photo-detector 27 or by manual advance) to decide whether to go to the next subsection or go back over the preceding one. If either photo-detector 27 or counters 59 signals that the ribbon is worn, or manual advance button 50 indicates ribbon transport regardless of ribbon condition, processor 47 reloads the counters 59 and signals the advance into the new subsection (blocks 61, 62). Otherwise, processor 47 toggles the direction flag, reloads the Δx count for the subsection and begins to go back over the preceding subsection (blocks 63, 64).

In summary, the length of each ribbon subsection (ΔL) is set by the operator during a power-up or RESET operation. While the printer is printing, microprocessor 47 is supervising the uniform wearing of the ribbon subsection by slowly moving the ribbon back and forth by small increments (Δx) every few carrier returns. When a ribbon advance is signalled, the processor causes the ribbon to be transported to the next subsection and repeats the process.

The only other incident which can cause an interrupt to microprocessor 47 is the pushing of the RESET button 67 by the operator. This causes microprocessor 47 to enter the interrupt routine of Fig. 8, loading new parameters (ΔL , counter limits) into storage (blocks 66 and 68). When RESET button 67 was pushed, processor 47 assumes that a new ribbon has been installed. Therefore, the printer must be off-line when this happens.

A DEFAULT button 69 may be provided which has essentially the same consequences when pushed as RESET button 67, except that the new parameters are read from a default list stored in the non-volatile memory 48.

Fig. 10 shows the design principle for the counters 59 of Fig. 7. The purpose of the counters is to determine the actual number of impacts performed on each of the colour bands of ribbon 18 and to cause ribbon advance to a new ribbon subsection when the predetermined maximum number of impacts is surpassed.

As mentioned before, print head 12 is assumed to have seven print wires and, accordingly, there

will be seven control lines 70 for activating the print wire magnets. These control lines 70 are also connected to a discrete logic unit 71 which also receives vertical position control signals over lines 72 from the ribbon transport mechanism 73. A clock signal from system clock 74 via line 75 synchronizes logic unit 71 with the rest of the printer. Depending on which colour band 21 through 24 is selected, logic unit 71 enables the appropriate one of counters 76 through 79 which then decrements by the number of times the associated colour band is impacted by a print wire. The counters 76 through 79 may be implemented as binary counters, with the proviso that each counter comprises two sections (a) and (b), respectively counting the least and most significant bits. The input to counters 76 through 79 as well as the most significant bits are continuously mapped in map section 80 of memory 48 so as to permit the system to remember after a power-down which were the latest counts for each of the colour bands 21 through 24.

At power-up either the maximum count predetermined for each colour will be set into its associated counter, if the ribbon subsection is fresh, or the current count reached at the last power-down will be set, if the subsection was already used for printing. As one of the counters is decremented to zero, processor 47 will notice and cause a fresh ribbon subsection to be brought in printing position.

The human interface to the printer can vary widely with the kind of printer used. The essential elements of the human interface are shown in Fig. 7 and comprise ribbon advance button 50, RESET button 67, DEFAULT button 69, a visual display 81 for displaying a numerical output from microprocessor 47,—this display might, e.g. use light emitting diodes, a ΔL button 82, and a set of microswitches 83 or the like for entering said predetermined counts for each one of the colour bands into microprocessor 47. An alternative to those microswitches 83 would be an appropriate set-up mode preprogrammed so as to write the values direct into random access memory 49.

The mechanisms described above can be implemented on existing and future systems in a variety of different ways all leading to the performance of the method in accordance with the invention. It will be obvious to those skilled in the art that the ribbon subsection control described can be implemented as a separate unit interfacing the printer at the power supply, the print control lines and the ribbon transport mechanism. It may also be fully integrated into a host printer, if the printer is run from a microprocessor. In this case, besides the addition of a few components, the program code for the host microprocessor will have to be modified. In printers without a keyboard the human interface of Fig. 7 may be used. Where there is a keyboard on the printer, the entire human interface could be integrated into the set-up mode of the printer. The availability of a microprocessor offers the

additional advantage to monitor and remember the quality status of all subsections of the ribbon at the time an advance to a fresh subsection was made so as to enable a possible return to those subsections which still would permit printing in a quality commensurate with the quality then required.

Claims

1. Method for adaptively using a print ribbon be it in single-colour or multi-colour impact printers, characterized by transporting, during printing operation, in forward and reverse directions by small increments (Δx), one subsection of predetermined length (ΔL) of the ribbon (18), continuously monitoring the condition of the colour(s) (21...24) in said one subsection, until the condition of said colour or any one of the colours (21...24) in said one subsection has reached a predetermined lower tolerance level, and then advancing the ribbon (18) so as now to expose at the printing station the subsequent, fresh subsection of the ribbon (18), regardless of the condition of the possibly remaining colours in said one subsection, for repeating the procedure until the entire ribbon is used up.

2. Method according to claim 1, characterized in that the condition of the colour track(s) is monitored by counting the number of printing impacts exercised on the colour track(s) in said exposed subsection, comparing the current count with a predetermined count representative of the exhaustion of the particular colour, and signalling the reaching of said predetermined count for advancing the ribbon (18) to expose its subsequent subsection at the printing station.

3. Method according to claim 1, characterized in that the condition of the colour track(s) is monitored by shining light (26) through said track(s) (21...24), passing the resultant light through a filter (28...31) associated with the colour track(s) (21...24) and adapted to filter out every colour except that of its associated track (21...24), supplying the light output from said filter(s) (28...31) to individual photo-sensitive elements (32...35) for determining the intensity of the light passing said filter(s) (28...31), feeding the output signals of said photo-sensitive elements (32...35) into associated integrators (36...39), and comparing the output from said integrators with predetermined thresholds special to each one of the colours used.

Patentansprüche

1. Verfahren zur anpassbaren Verwendung eines Farbbandes in Einfarben- oder Mehrfarben-Anschlagdruckern, gekennzeichnet durch während der Druckoperation erfolgreiches Transportieren eines Abschnitts vorbestimmter Länge (ΔL) des Bandes (18) in Vor- und Rückwärtsrichtung um kleine Inkremente (Δx), kontinuierliches Überwachen des Zustandes der Farbe(n) (21...24) des genannten Bandabschnitts, bis der

Zustand der genannten Farbe oder einer der Farben (21...24) in diesem Bandabschnitt eine vorgegebene untere Toleranzgrenze erreicht hat, dann Vorschub des Bandes (18), so dass nun an der Druckstation der folgende, frische Abschnitt des Bandes (18) zur Verfügung steht, unabhängig vom Zustand der gegebenenfalls übrigen Farben im erstgenannten Bandabschnitt, und Wiederholen des Vorgangs, bis das ganze Band verbraucht ist.

2. Verfahren gemäss Patentanspruch 1, dadurch gekennzeichnet, dass der Zustand der Farbspur(en) durch Zählen der Anzahl Anschläge überwacht wird, die auf die Farbspur(en) des exponierten Bandabschnitts ausgeführt werden, dass die Zählung mit einer vorgegebenen Anzahl verglichen wird, die für die Erschöpfung der betreffenden Farbe repräsentativ ist, und Signalisieren des Erreichens der vorgegebenen Anzahl zum Vorschub des Farbbandes (18), so dass an der Druckstation der folgende Bandabschnitt exponiert wird.

3. Verfahren gemäss Patentanspruch 1, dadurch gekennzeichnet, dass der Zustand der Farbspur(en) überwacht wird, indem Licht (26) durch die Farbspur(en) (21...24) fallen gelassen wird und das resultierende Licht durch ein der/den Farbspur(en) (21...24) zugeordnetes Filter (28...31) geleitet wird, das so ausgebildet ist, dass es jede Farbe ausser derjenigen der Farbspur (21...24), der es zugeordnet ist, ausfiltert, dass das von dem/den Filter(n) (28...31) durchgelassene Licht photoempfindlichen Elementen (32...35) zum Feststellen der Intensität des das/die Filter (28...31) passierenden Lichts zugeführt wird, und dass die Ausgangssignale der photoempfindlichen Elemente (32...35) ihnen zugeordneten Integratoren (36...39) zugeführt und die Ausgangssignale der Integratoren mit für jede der benützten Farben speziell vorgegebenen Schwellenwerten verglichen werden.

Revendications

1. Méthode d'adaptation et d'utilisation d'un ruban d'impression dans une imprimante à impact monochrome ou polychrome, caractérisée par l'entraînement pendant l'opération d'impression, en avant et en arrière, par petits incréments (Δx), d'une sous section de longueur prédéterminée (ΔL) du ruban (18), le contrôle continu de l'état de la ou des couleurs (21...24) de ladite sous section jusqu'à ce que l'état de ladite couleur ou de l'une quelconque des couleurs (21...24) de ladite sous section ait atteint un niveau de tolérance inférieur prédéterminé et par l'avancement du ruban (18) de façon à exposer maintenant à la station d'impression une nouvelle sous section de ruban (18) indépendamment de l'état des couleurs pouvant rester de ladite sous section, afin de répéter cette suite d'opérations jusqu'à ce que tout le ruban soit utilisé.

2. Méthode selon la revendication 1 caracté-

térisée en ce que l'état de la ou des pistes de couleur est contrôlé en comptant le nombre des impacts d'impression sur la ou les pistes de couleur de ladite sous section exposée, en comparant le compte courant à un compte prédéterminé représentant la disparition de la couleur particulière et en signalant l'atteinte dudit compte prédéterminé pour avancer le ruban (18) afin d'exposer sa sous section suivante à la station d'impression.

3. Méthode selon la revendication 1 caractérisée en ce que l'état de la ou des pistes de couleur est contrôlé en appliquant de la lumière (26) au travers de la ou desdites pistes (21 . . . 24), en faisant passer la lumière résultant au travers

d'un filtre (28 . . . 31) associé à la ou les pistes de couleur (21 . . . 24) et prévu pour filtrer toutes les couleurs à l'exception de celle de sa piste associée (21 . . . 24), en appliquant la sortie lumineuse desdits filtres (28 . . . 31) à des éléments photosensibles individuels (32 . . . 35) pour déterminer l'intensité de la lumière passant au travers desdits filtres (28 . . . 31), en envoyant les signaux de sortie desdits éléments photosensibles (32 . . . 35) dans des unités d'intégration associées (36 . . . 39) et en comparant la sortie desdites unités d'intégration à des seuils prédéterminés particuliers à chacune des couleurs utilisées.

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15

20

25

30

35

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60

65

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FIG. 1

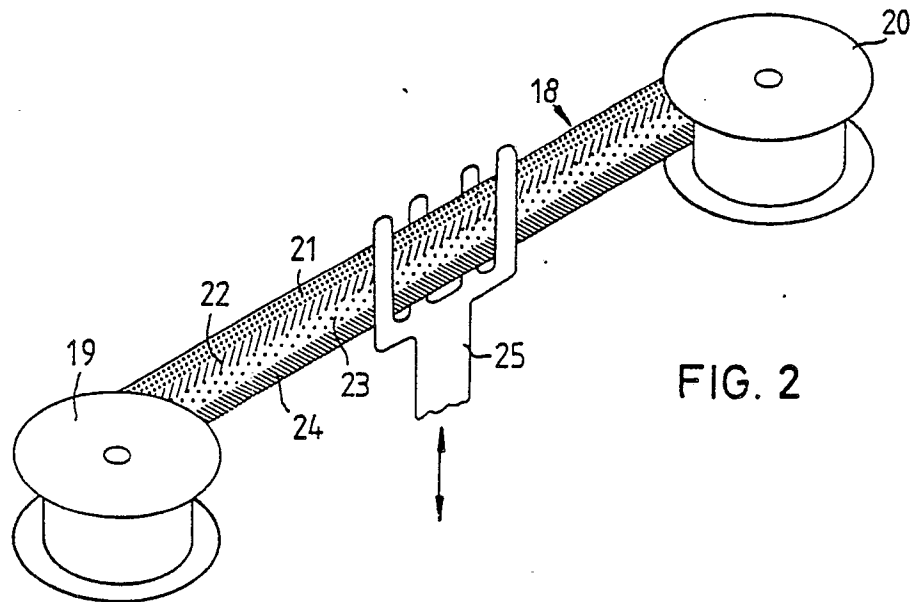
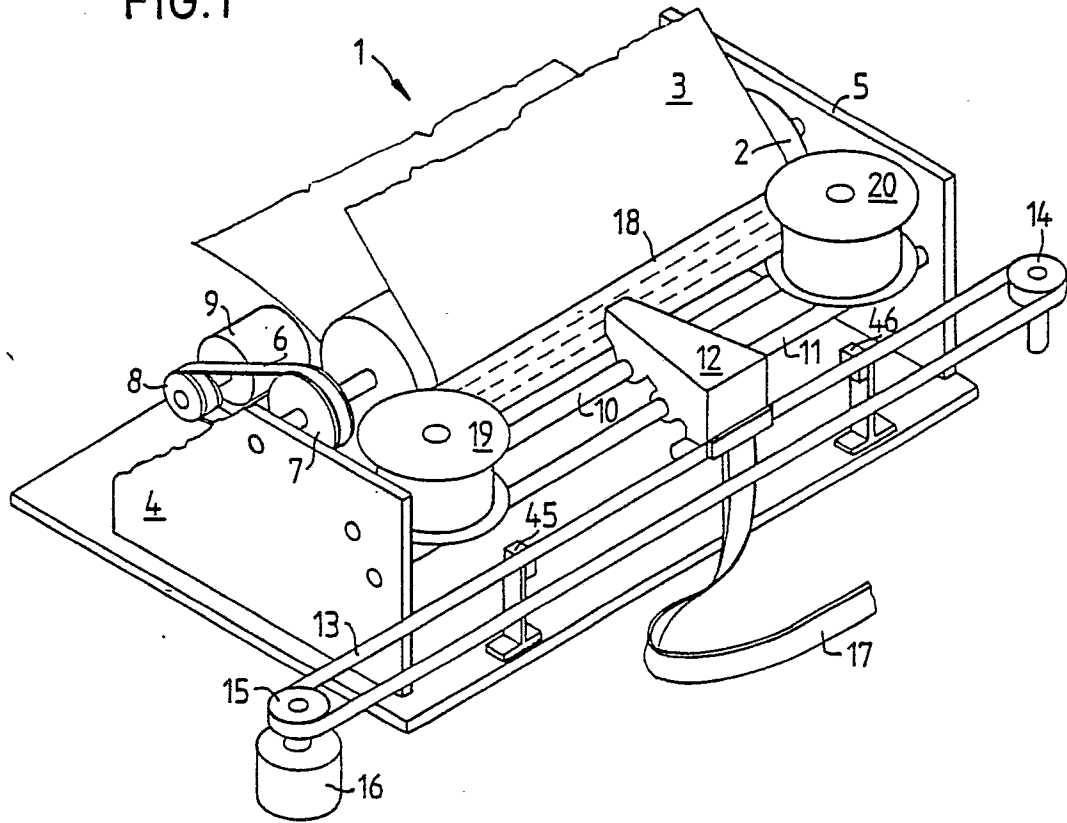
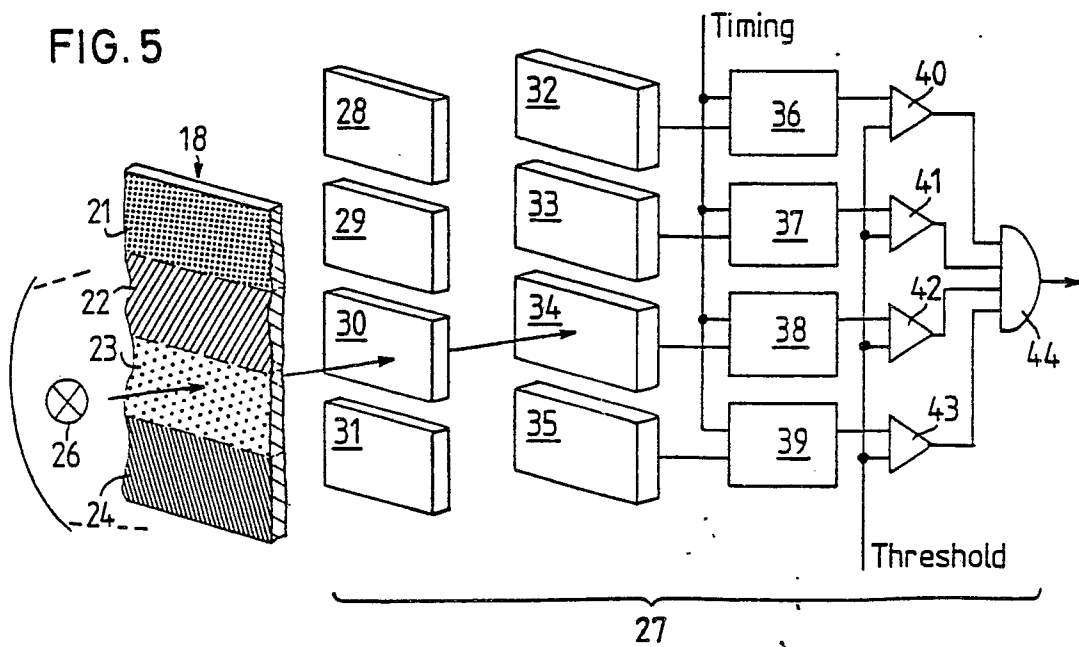
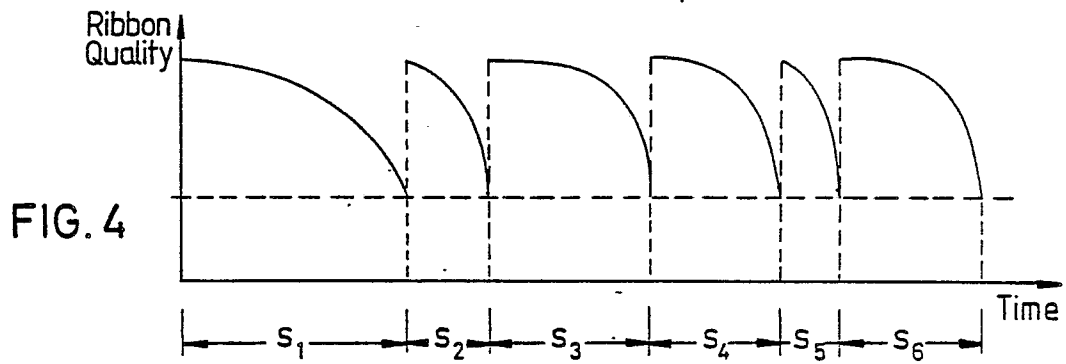
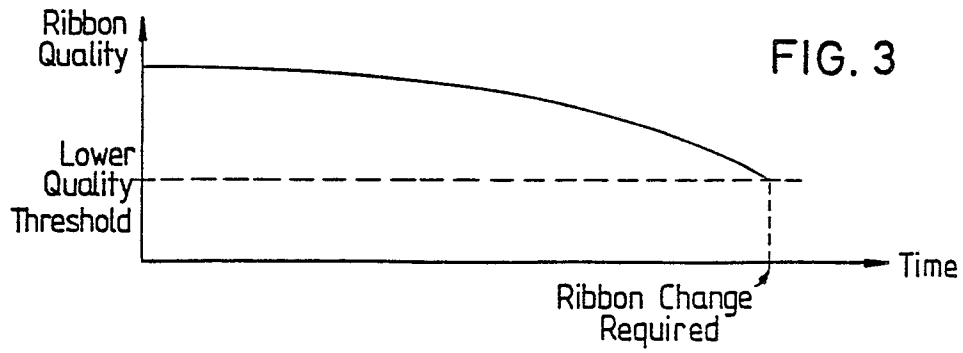


FIG. 2



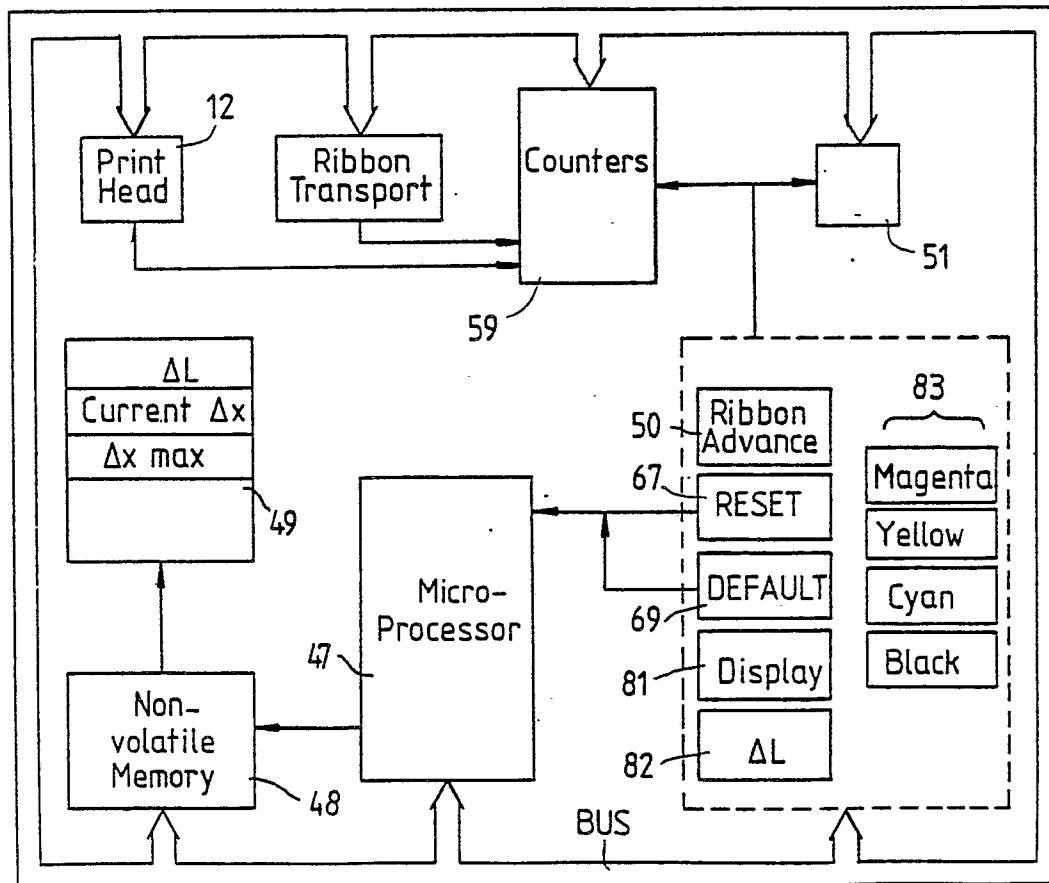
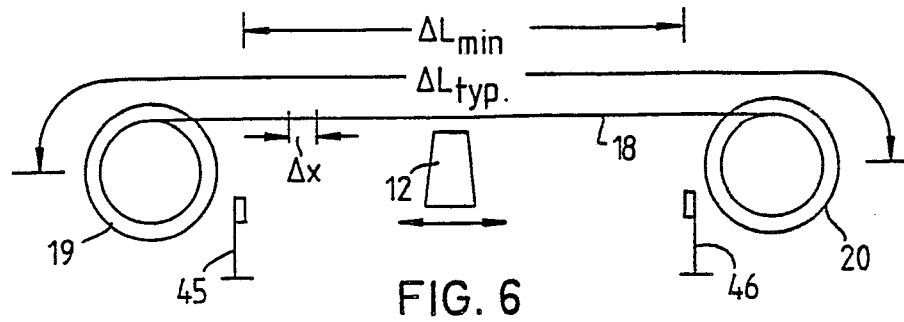


FIG. 8

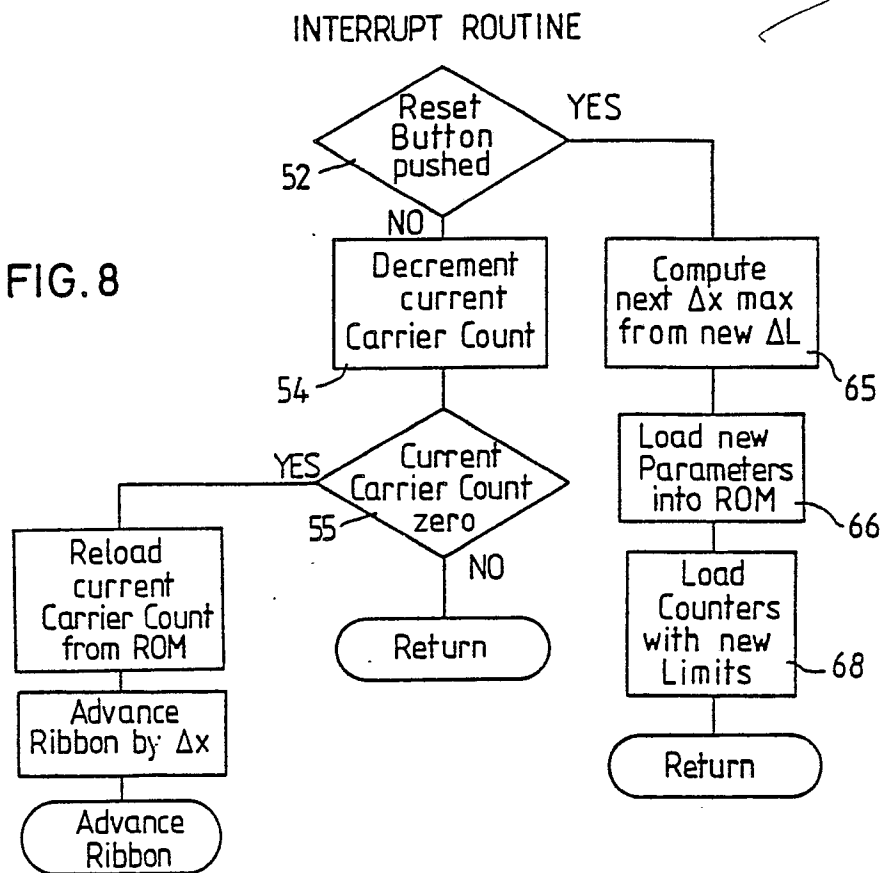


FIG. 10

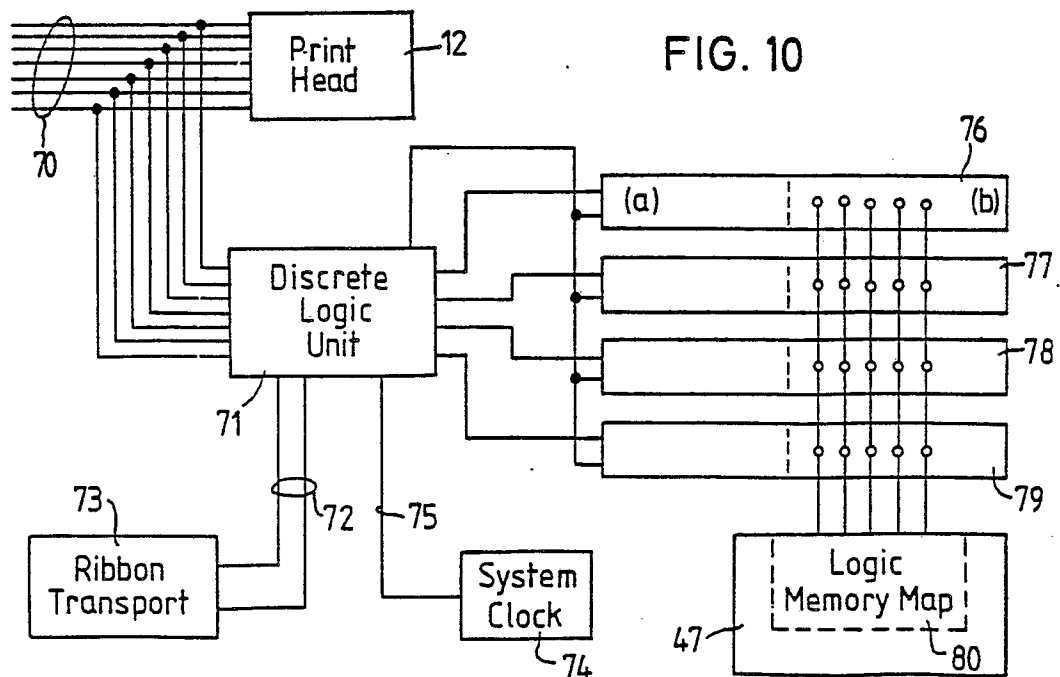


FIG. 9

