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(54) **Dot matrix printer.**

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Description

Field of the invention

This invention relates to impact printing and in particular to impact line printers which employ dot patterns in the printing operation to record dots on a print medium to form characters, images symbols, lines or the like.

Background of the invention

Dot matrix printers may be of various diverse type, such as chain type printers, helical printers and band printers.

One type of such a chain printer is described in US—A—3.888.148, in which the print chain is provided with differently formed and arranged printing elements (surfaces). The print elements are formed and positioned so that any optional programmed character can be printed in matrix form.

A dot-helix matrix printer, which is an enhancement of the bar-helix printer, consists of a rotating cylinder having rows of single raised dot print elements formed in a helical pattern around the peripheral surface. A plurality of print hammers having a bar-shaped impact surface is provided. A paper print medium is continuously fed between the hammers and the cylinder. Actuators are provided which selectively actuate the hammers to strike the dot print elements against an ink ribbon and paper whenever one of the dot elements is in position to be printed to record printed dots on the paper.

Band matrix printers employ single raised dots distributed along a band or belt which moves horizontally across the paper to be printed. GB—A—1.493.719 describes such a band printer, in which the print belt is provided with sets of staggered print elements. EP—A—43.434 describes another type of band printer in which the print belt is provided with a plurality of dot font sizes and shapes.

Another form is a drum printer which has raised dots distributed in columns around a drum which rotates around an axes parallel to the line to be printed. In both cases, printing is achieved by impacting the raised dot printing elements with a print hammer which results in the raised dots impacting a printing ribbon against paper and transferring ink or printing dots at the position of the dots when the paper is contacted. Patterns are printed by striking the hammers against the printing belt or drum whenever one of the dot printing elements, which move along the printing line, is in a position where a printed dot is desired. In this way, any desired pattern is formed by an array of dots which are printed along a line. Subsequent lines are printed by stepping the paper vertically or normal to the printing line.

It is well known that one limitation on the printing speed of impact printers such as impact line printers is the cycle time of the print hammer or maximum repetition rate of the pattern of the print elements on a dot-helix cylinder or on a belt, band or drum. It became apparent that it would be advantageous if the printer throughput could be improved for a given hammer repetition rate.

Summary of the invention

The present invention makes use of multiple dot patterns distributed on the cylinder, belt, band or drum of a line printer to provide an improved printing throughput for an all points addressable line printer.

In a dot-helix matrix printer, different arrangements of the dots are used which can be varied in position and spacing to increase printing speed. By using a 1, 2, 1, 2, dot pattern, a 66% printing speed and a 33% power saving is realized over the use of a single dot pattern. The use of a 1, 2, 1, 3, dot pattern results in a speed improvement of 100% over the single dot pattern.

On a belt, band or drum line printer, multiple dot patterns are given a predetermined distribution. More specifically, arrangements of dots are used which provide enhanced performance due to the fact that they are determined by an analysis of the statistical occurrence of a particular dot pattern in a character set. The higher statistical probability dot patterns are used more often on the belt, band or drum. For example, assume pattern 1 consists of a dot in the upper case position, pattern 2 consists of a dot in the lower case position and pattern 3 consists of dots in both the upper and lower case positions. If it is found that, for the character set for a particular application, pattern 1 occurs statistically more often than the other two patterns, then pattern 1 can be used more often and distributed in more places on the belt, band or drum.

The above-described example included a pattern with two rows (m=2) and one column (n=1) with three possible patterns. The general case for any number of rows and columns is $2^{mn}-1$ possible patterns. The particular patterns that are used and distributed more often will depend on a statistical analysis of whatever character set is to be employed.

The foregoing and other objects, features and advantages of the invention which is defined in the attached claim 1 will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

Brief description of the drawings

Figure 1 is a diagrammatic view showing a basic single dot pattern arranged in a helical array on a cylinder of a dot-helix matrix printer.

Figure 2 is a diagrammatic view showing the dot matrix arrangement for the printed character "E".

Figure 3 is a diagrammatic view showing a 1, 2, 1, 2, dot pattern arranged in a helical array on the cylinder of Figure 1.

Figure 4 is a diagrammatic view showing a 1, 2, 1, 3 dot pattern arranged in a helical array on the cylinder of Figure 1.

Figure 5 is a diagrammatic view showing a bar pattern arranged in a helical array on the cylinder of Figure 1.

Figure 6 is a diagrammatic view showing one configuration of a single dot pattern on a belt of a band matrix printer.

Figure 7 is a diagrammatic view showing one configuration of a vertical multidot pattern arrangement on a belt of a band matrix printer.

Figure 8 is a diagrammatic view illustrating the 3 vertical dot patterns shown in the arrangement of Figure 7.

Figure 9 is a diagrammatic view illustrating the dot patterns shown in the arrangement of Figure 8 with one of the dot patterns being used more frequently than the others.

Figure 10 is a diagrammatic view illustrating a horizontal arrangement of 3 dot patterns on a belt of a band matrix printer.

Figure 11 is a diagrammatic view illustrating a horizontal arrangement of 2 of the dot patterns shown in Figure 10.

Figure 12 is a diagrammatic view illustrating 7 dot patterns that could be arranged horizontally on the belt of a band matrix printer.

Figure 13 is a diagrammatic view illustrating a horizontal arrangement of 4 of the dot patterns shown in Figure 12.

Description of preferred embodiments

Referring to Figure 1, there is illustrated a rotating cylinder 10 of a dot-helix matrix printer. A row of single raised dot print elements 11 is shown formed in a helical pattern around the peripheral surface of the cylinder. A plurality of similar rows would be disposed along the cylinder, there being one row for each character print position.

A printer hammer 12 having a bar-shaped impact surface is provided for each row of dot print elements. It is not shown, but it is well known that a paper print medium is continuously fed vertically between the rotating cylinder and print hammers. Magnetically operated actuators are provided which selectively actuate the hammers to strike the dot print elements against an ink ribbon and paper whenever one of the dot elements is in position to be printed to record printed dots on the paper.

Taking the basic dot pattern shown in Figure 1, assume the print hammers repetition rate is fixed at 1 ms. and the vertical spacing between dots is 0.05 cm and the cylinder is rotating at a surface speed of 50 cm/sec. For a 5 by 7 character printing, it takes 6 ms to complete a horizontal row of dots and 42 ms to print a character. There are 5 dots per character and 1 dot spacing between characters. To print a 5 by 7 character "E", shown in Figure 2, will require the hammer to strike 18 times.

In accordance with the present invention, by arranging different dot patterns on the cylinder, the printing speed and power consumption can be improved. One example is shown in Figure 3 wherein the dot elements are disposed in a 1, 2, 1, 2, arrangement. The vertical spacing between dots is maintained at .05 cm. With the hammer repetition rate fixed at 1 ms. and the cylinder now rotating at a surface speed of 150 cm/sec., the dot pattern is so arranged that the hammer is never required to strike within 3 rows of dots (1 ms). To print a 5 dot row now requires 4 ms. instead of 6 ms., as is the case for the pattern shown in Figure 1. A printing speed increase of 66% is realized. To print the character "E", shown in Figure 2, requires only 12 hammer strikes instead of 18. This results in a power saving of 33%.

The printing speed can be further improved by different arrangements of dot patterns. For example, a 1, 2, 1, 3, pattern is shown in Figure 4. Assume the same fixed parameters and the cylinder rotating at a speed of 200 cm/sec. It now requires only 3 ms. to print a 5 dot line resulting in a 100% speed improvement. To print the character "E", shown in Figure 2, now requires only 10 hammer strikes. Other designs of dot patterns for different resolutions can achieve similar printing speed improvements.

It will be understood that the embossed patterns do not have to be in dot form. They can be extended to bar forms to further improve the print quality. The bar pattern shown in Figure 5 can be used to replace the dot pattern shown in Figure 3. Solid line printing can be achieved with overlapping dots or bars.

In another embodiment of the present invention, multiple dot patterns are distributed on a belt, band or drum of a line printer to provide an improved printing throughout for an all points addressable line printer. Referring to Figure 6, there is shown one configuration of a "single dot" band printer in which the hammer 13 can strike a single raised dot print element 14 at any one of seven locations across the hammer. The dot print elements are spaced at intervals of eight print positions along the belt 15 so that no two dots are in front of a print hammer simultaneously. The belt moves horizontally across a paper print medium to be printed. Printing is achieved by impacting the raised dot print elements to a printing ribbon against the paper and transferring ink or printing dots at the position of the dots when the paper is contacted. Patterns are printed by selectively energizing magnetic actuators to effect the striking of hammers against the printing belt or drum whenever one of the dot print elements, which move along or across the printing line, is in a position where a printed dot is desired. The number of hammers employed can vary and depends on the number of characters to be printed per line and the spacing between dots. In this way, any desired pattern is formed by an array of dots which are printed along a line. Subsequent lines are printed by stepping the paper vertically or normal to the printing line.

Referring to Figure 7, there is shown a simple multidot belt pattern for the case m=2, n=1, where m corresponds to the number of rows and n the number of columns in the dot patterns distributed around the belt. This pattern comprises dot P1 in the upper case position, dot P2 in the lower case position, and dots P3 in both the upper and lower case positions. Figure 8 shows the same pattern in shaded square form for purposes of illustration. P1, P2 and P3 would be arranged around the belt as shown.

In order to print a line of characters where each character consists of dots printed on an M×N matrix and the print elements consist of dots distributed on an m×n matrix the printing time is given by

$$T=S\times(M/m)\times(N/n)\times T_r+(M/m)\times T_p$$

where

T_r=Hammer repetition rate

T_p=Paper advancing time

S=A function which varies dependent on the initial position of the dot patterns relative to the printed information.

The factor S is unity for a single dot pattern and S>1 for a multidot band. It increases the further the initial position of the required dot pattern is from the position to be printed. In order for the printing throughput to be better than the single dot case, it is desirable that (S/mn) decreases to less than one. If this ratio is less than one, the multidot pattern will be definitely better than the single dot pattern. Even if this ratio is not less than one, if the $(M/n)\times T_p$ term reduces the paper advance time to the extent that the total time is less, then the multidot pattern is still better than the single dot case. The factor S reduces if the belt speed is higher or if the statistics for the multidot patterns are skewed. The latter is the essence of the present invention, as described later.

Considering the printing of an alphanumeric character set as a 8×7 matrix with a single dot band and a 3-patterns or m=2, n=1 band under conditions of T_r=1 msec and T_p=5 msec. The single dot band requires 56 msec for the printing operation and 40 msec to advance the paper, for a total printing time of 96 msec.

Now for the multidot case with m=2, n=1, the average printing speed for all characters of the alphanumeric set is 43.424 msec. This results in an average improvement of 54.7%. However, it is realized that this printing speed improvement requires an eight fold increase in the belt speed but an overall decrease in the number of actual hammer firings per printed job. Further increase in the belt speed will further increase the print throughput. The essence is that even if the belt speed is increased, the throughput will not increase for the single dot belt.

The approach described above is an extension of the single dot band (belt, drum) printing concept to multidot elements. What follows, however, is a general description of methods which can be employed to produce further overall printing throughput increases. Methods which involve the use of the statistics related to the desired printed character set, the language to be printed and ultimately the type of printing jobs. This exposition is not exhaustive, but indicates the methods that are to be employed when designing a multidot printer.

Considering a multidot belt printer as shown in Figures 7 and 8, with m=2, n=1, the number of independent patterns on the belt is three. Considering, the entire character set described earlier the number of times each pattern occurs is:

P1=231

P2=134

P3=111

It thus appears that for printing the entire alphanumeric set when each character has an equal probability of occurrence, a belt (band or drum) which has a greater number of patterns type P1 than P2 or P3 will give greater printing throughput. Such a pattern is shown in Figure 9 as P1, P2, P1, P3.

Comparing a multidot printer m=2, n=1 which does not employ the statistical distribution of the patterns involved in the character set with a multidot belt printer which does take into account this fact, there is obtained for a sequential printing operation; i.e., characters printed from left to right, the following printing speeds. Non-statistical belt with three patterns P1, P2, P3 distributed periodically around the belt.

Average print speed: 24.424 msec/character line

Worst case printing speed: 34.125 msec/character lines

Statistical belt with patterns distributed P1, P2, P1, P3 cyclically around the belt. The number of cycles of 4 pattern positions is based on the length of the belt.

Average Print Speed: 23.878 msec/character line

Worst Case Print: 34.125 msec/character line

For random printing, i.e., a pattern is struck as it arrives at the correct printing position (no left to right requirement), the printing speeds become;

Non-statistical belt: 21.47 msec average, 33.75 msec worst case

Statistical Belt: 21.114 msec average, 31.25 msec worst case

Further improvement may be possible by considering the fact that not all characters are equally probably used in any language. Also, the relative positions of dot patterns on the belt (in any given dot pattern cycle or between cycles) can influence the overall printing speed through the statistical probability of occurrence (i.e., dependent probabilities) associated with a given dot pattern immediately preceding or following any other dot pattern. Finally any statistical skew that may be associated with a given type of printing operation (e.g., insurance, air lines, payroll, etc.) can also be factored into the statistics of the dot pattern distribution.

Referring to Figures 10—13, patterns are shown distributed in a horizontal row around the belt. In the case of a horizontal distribution, the number of patterns is 2^n-1. For the case where n=2, there are three patterns P1, P2, and P3, as shown in Figure 10. However, patterns P1 and P2 are redundant so that only patterns P1 and P3 need be used, as shown in Figure 11. Figure 12 illustrates the seven patterns P1—P7 which would be the case where n=3. In this case, patterns 1 and 3, 4 and 6 are redundant and only patterns P1, P4, P5 and P7 need be used, as shown in Figure 13.

It will be understood that the present invention is not limited to the specific patterns shown and described. These patterns may be varied to meet the requirements of different printing applications.

Claims

1. A multidot printer system having a print element carrying member (12) including raised dot print elements forming a character set in the form of repeated sets of dot patterns (Figure 3, 4, 5) distributed around said carrying member, characterized in that the number of separate dot patterns in each character set is determined by the number of rows and the number of columns in the dot pattern, and that the separate dot patterns are distributed around said carrying member (12) at a frequency substantially proportional to their statistical probability of occurrence during printing.

2. A printer system according to claim 1, wherein said raised dot print elements in each set may be arranged in $2^{mn}-1$ possible patterns where m corresponds to the number of rows and n to the number of columns in the distribution of the dot patterns.

3. A printer system according to claim 1, wherein said raised dot elements in each set may be arranged in 2^n-1 possible patterns where n corresponds to the number of columns in the distribution of the patterns.

4. A printer system according to claims 1 to 3, wherein said print element carrying member (12) is a drum.

5. A printer system according to claims 1 to 3, wherein said print element carrying member is a band.

6. A printer system according to claims 1 to 3, wherein said print element carrying member is a belt.

Patentansprüche

1. Punktmatrixdrucker mit einem Druckelement-Trägerteil (12), das über erhabene Druckpunktelemente verfügt, die einen Zeichensatz in Gestalt von widerholten Punktmustersätzen (Fig. 3, 4, 5) bilden, welche um das Trägerteil herum verteilt sind, dadurch gekennzeichnet, daß die Zahl der getrennten Punktmuster in jedem Zeichensatz durch die Zahl der Zeilen und die Zahl der Spalten im Punktmuster bestimmt ist, und daß die getrennten Punktmuster um das Trägerteil (12) herum mit einer Häufigkeit verteilt sind, die im wesentlichen proportional ihrer statistischen Auftrittswahrscheinlichkeit während des Druckens ist.

2. Drucker nach Anspruch 1, dadurch gekennzeichnet, daß die erhabenen Druckpunktelemente in jedem Satz in $2^{mn}-1$ mögliche Muster angeordnet werden können, wobei m der Zahl der Zeilen und n der Zahl der Spalten in der Verteilung der Punktmuster entspricht.

3. Drucker nach Anspruch 1, dadurch gekennzeichnet, daß die erhabenen Druckpunktelemente in jedem Satz in 2^n-1 mögliche Muster angeordnet werden können, wobei n der Zahl der Spalten in der Verteilung der Punktmuster entspricht.

4. Drucker nach den Ansprüchen 1 bis 3, dadurch gekennzeichnet, daß das Druckelement-Trägerteil (12) eine Trommel ist.

5. Drucker nach den Ansprüchen 1 bis 3, dadurch gekennzeichnet, daß das Druckelement-Trägerteil (12) ein Band ist.

6. Drucker nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß das Druckelement-Trägerteil (12) ein Druckzeichen-Gürtel ist.

Revendications

1. Système d'imprimante à points multiples comprenant un organe (12) porteur d'éléments d'impression qui comporte des éléments d'impression à point en relief constituant un jeu de caractères, sous la forme de groupes répétés de configurations de points (figures 3, 4, 5) répartis autour de l'organe porteur, caractérisé en ce que le nombre de configurations de points distinctes dans chaque jeu de caractères est déterminé par le nombre de rangées et le nombre de colonnes dans la configuration de points, et en ce que les configurations de points distinctes sont réparties autour de l'organe porteur (12) à une fréquence sensiblement proportionnelle à leur probabilité statistique d'exécution pendant l'impression.

2. Système d'imprimante suivant la revendication 1, dans lequel les éléments d'impression à point en relief dans chaque groupe peuvent être agencés en $2^{mn}-1$ configurations possibles, où m correspond au nombre de rangées et n au nombre de colonnes dans la répartition des configurations de points.

3. Système d'imprimante suivant la revendication 1, dans lequel les éléments à point en relief dans chaque groupe peuvent être agencés en 2^n-1 configurations possibles où n correspond au nombre de colonnes dans la répartition des configurations.

4. Système d'imprimante suivant les revendications 1 à 3, dans lequel ledit organe (12) porteur d'éléments d'impression est un tambour.

5. Système d'imprimante suivant les revendications 1 à 3, dans lequel ledit organe porteur d'éléments d'impression est une bande.

6. Système d'imprimante suivant les revendications 1 à 3, dans lequel ledit organe porteur d'éléments d'impression est une courroie.

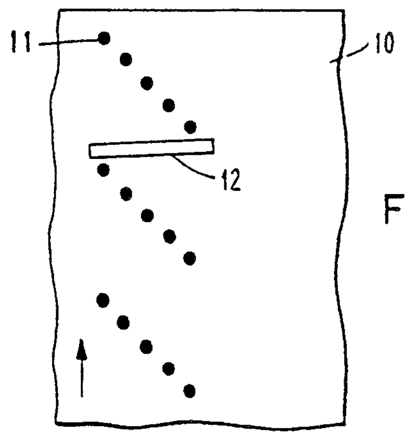

FIG. 1

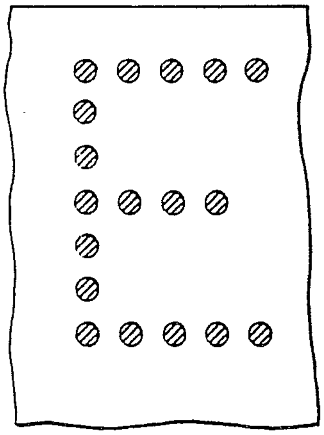

FIG. 2

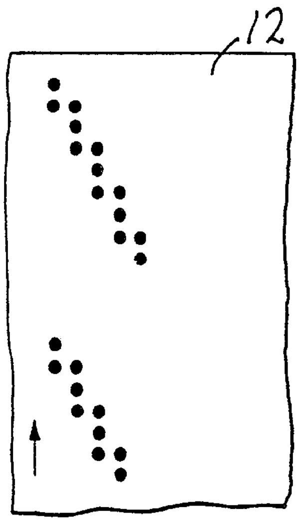

FIG. 3

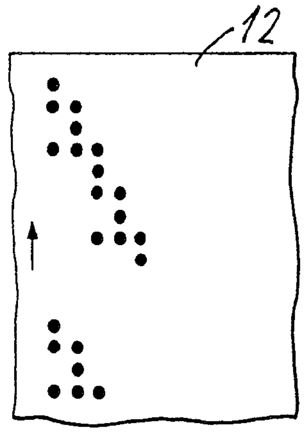

FIG. 4

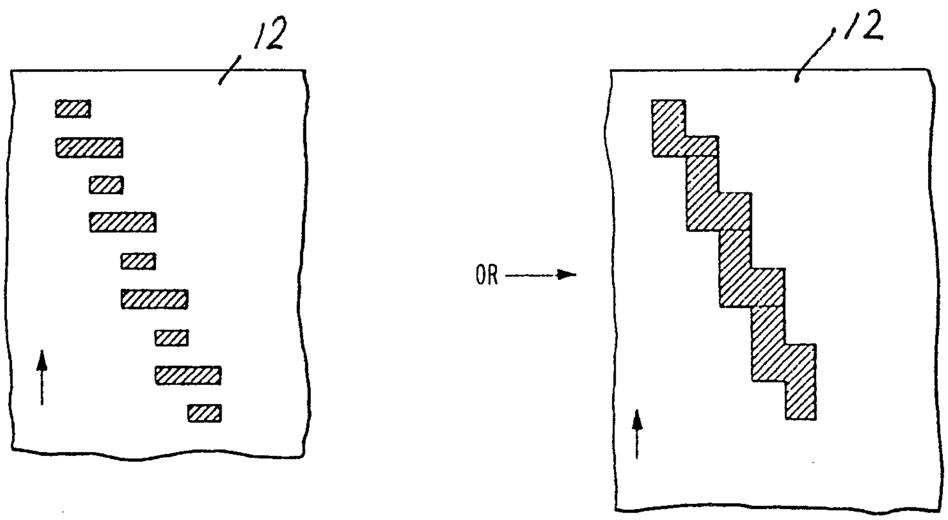

FIG. 5

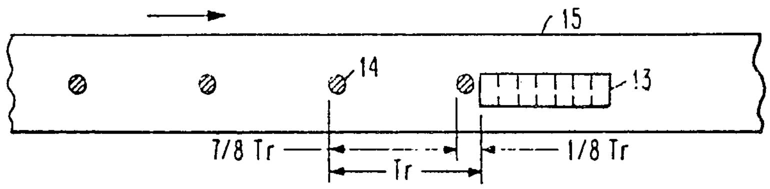

FIG. 6

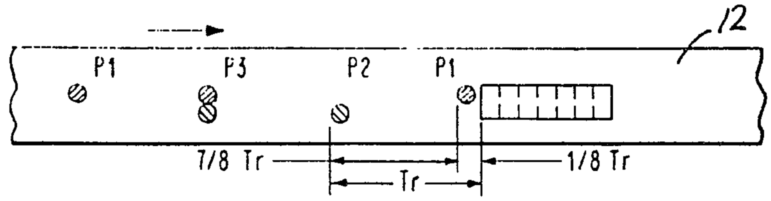

FIG. 7

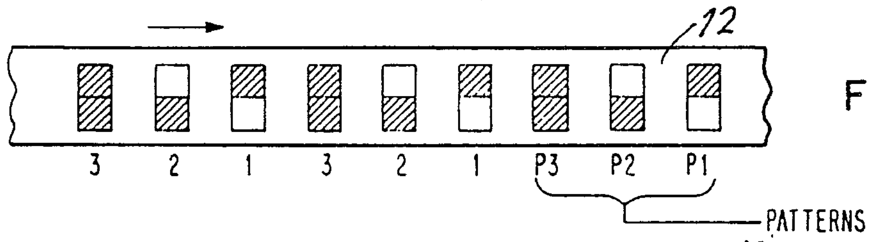

FIG. 8

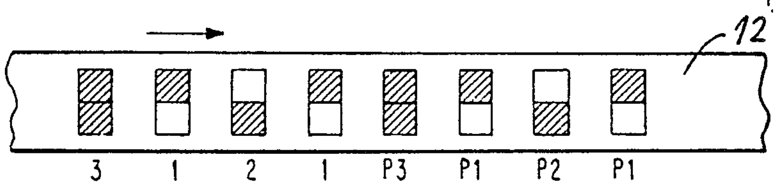

FIG. 9

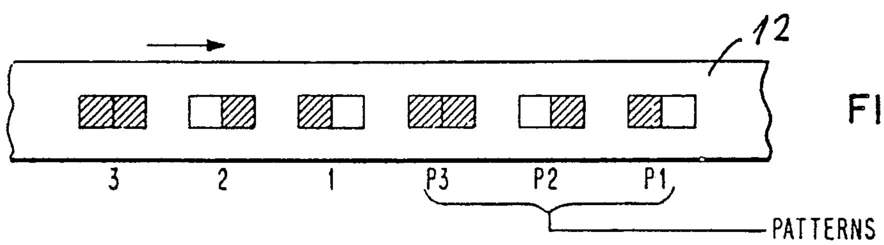

FIG. 10

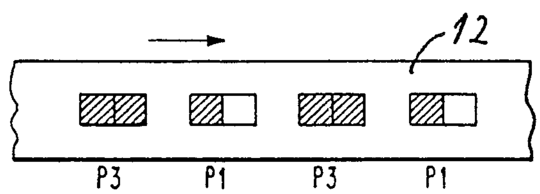

FIG. 11

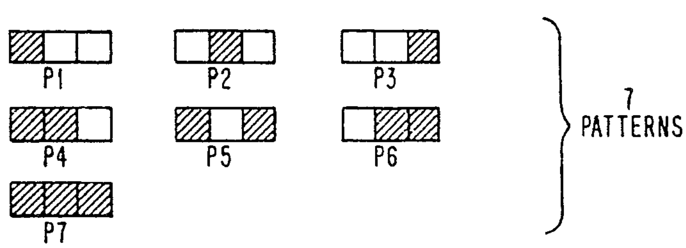

FIG. 12

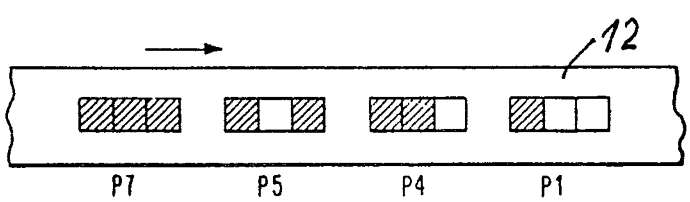

FIG. 13