The invention relates to a picture reproduction system for producing a digital picture according to the preamble to claim 1.

A picture reproduction system of this type is already known from EP-A-0 033 106. This known picture reproduction system comprises:

- a data store, containing a picture store and a text store,
- a laser printer for printing out picture element data held in the picture store and/or text data stored in the text store with the aid of a laser diode,
- two line stores for storage of data for two successive lines in the picture,
- a counter,
- an OR circuit, via the output of which a laser beam emitted by the laser diode is modulated, and
- a computer for operational control.

Furthermore, a picture processing system is known from US-A-4 370 667, which comprises a counter, whose counting value is reset for successive picture element data along each line of the picture to a value corresponding to the grey value for a picture element and thus supplies a counter output signal which is proportional to the respective grey value. An AND circuit is also provided which receives the counter output signal at one input and in this case transmits a high-frequency signal from a high-frequency oscillator to a laser diode of a laser printer.

It is generally known from US-A-3 757 036 for the bars or lines which are used in the case of half-tone pictures for production of grey tones in the picture elements to be not only aligned with one another but also contiguous with one another, in order to prevent the occurrence of spaces between the lines.

Furthermore, the use of line stores per se is known from GB-A-2 078 050.

The object of the invention is to develop the aforementioned picture reproduction system in such a way that the grey values can be set in the individual picture element areas with an electronic device which is more simply designed and therefore cheaper to manufacture.

The solution to the defined object is described in the characterising part of claim 1. Advantageous embodiments of the invention can be found in the subclaims.

The picture reproduction system according to the invention is characterised in that

- the two line stores are connected on the input side to the picture store and on the output side to the counter in order to be loaded alternately with the picture element data and then to supply the latter to the counter, when the other line store is being loaded,

- the output of the counter is connected to an input of the OR circuit, the other input of which receives a text signal obtained from the text data from the laser printer, and

- the counting value of the counter for successive picture elements along each line of the picture is reset each time to a value corresponding to the respective grey value for a picture element, so that the counter supplies a counter output signal switching on the laser diode until the counting value has reached zero.

It is advantageous if the counter is always reset when a cycle setting counter has passed through a predetermined number of counting steps, which determines the size of a picture element in the direction of the picture line. If, for example, a picture element is made up of four pixels in the form of a square, the picture element cycle comprises two pixel widths. In the case of picture elements with one pixel only, the picture element cycle comprises one pixel width. The counter is then set at the beginning of each cycle to a counting value which corresponds to the density value of the picture area which is to be reproduced by the picture element.

The picture element data of a picture line must be read out repeatedly, in conformity with the size of the picture element, until the number of pixels in the Y-direction (direction of transport of the picture carrier) is equal to the number of pixels in the X-direction (direction of the print line). Of course, the cycle counter can also be set so that its cycle for picture elements with one pixel only is less than the pixel cycle, or that, in the case of picture elements with more than one pixel, it is less than the picture element cycle. The counting value of the counter for the line or bar width must then be reduced accordingly (fig. 3 (a), right-hand side).

According to a particularly advantageous embodiment of the invention, a table store, in which is stored the relationship between the grey value determined by the picture element data and the counter value required for production of this grey value, which is supplied to the counter on input of the picture element data, is arranged between the outputs of the additional line stores and the input of the counter. The required counter value can be calculated very quickly by means of this table store.

The invention is described below in greater detail with reference to the drawing, where:

Figure 1 shows a section of a data field, stored in a picture store, for a picture with individual picture areas,

Figures 2 (a) to 2 (c) show picture elements, each used for the reproduction of one picture area of the data field,

Figures 3 (a) to 3 (c) are diagrams which explain the setting of the width of a line within a picture element corresponding to a predetermined density value,

Figure 4 shows the relationship between density and a counting value of a counter for line broadening,

Figure 5 shows a block diagram of a picture reproduction system, and

Figure 6 comprises various diagrams of signal patterns to explain the mode of operation of the cycle setting counter and the counter for broadening lines within the picture elements.

Figure 1 shows a diagram of a picture store 1, in which a data field 2 with several picture areas 3 of a picture is stored. Picture element data are allocated to each picture area 3, indicating a grey value or density value S for the respective picture area 3.

Figures 2 (a) to 2 (c) show picture elements such as those which are created in order to reproduce the digital picture. According to figure 2 (a), each picture element consists of one pixel 5. In the pixel 5 shown on the left, a line 6 is present on the left-hand edge, the longitudinal direction of which runs in the direction of transport of the picture carrier 7 (cf. figure 5), i.e. in this case in the Y-direction of the picture carrier 7. The width of the line 6 on the other hand extends in the direction of the print line of the laser printer 10, i.e. in the X-direction at right-angles to the Y-direction. This width of the line 6 present within the pixel 5 is set in conformity with the density value S which is allocated to the picture area 3, which is to be reproduced by means of the pixel 5. The line width can be set in steps, the width of each step corresponding to 1/32 of the pixel width. This means that a total of 32 + 1 different grey values can be produced within the pixel 5.

Two lines 6a and 6b are present within the pixel 5 shown on the right in figure 2 (a), by means of which a grey value S can also be produced similar to that obtained with the aid of the pixel 5 on the left in figure 2 (a).

If the picture areas 3 of the data field 2 are reproduced by pixels 5 of this type, the lines 6 or 6a, 6b lie in the Y-direction behind and aligned

with one another, and their front ends can furthermore be contiguous. By applying toner material to the latent picture constituted by the pixels 5, virtually no transitions occur in this case between pixels which are adjacent to one another in the Y-direction, so that no lines of interference run in the X-direction in the reproduced picture. Each line of the picture can, however, also be displaced in relation to the previous line in the direction of the picture line in order to produce other desired grid patterns.

Resolution, linearity and dynamics or density range are relatively great, since the pixels are small and the grey value S can be set within a pixel 5 with precision due to the fine divisibility of the line width.

Figure 2 (b) shows two picture elements 4a, 4b, each made up of four pixels 5 in the shape of a square. The left-hand edge of picture element 4a contains a line 8 which extends longitudinally over virtually two print lines of the laser printer 10. Picture element 4b contains two lines 8a, 8b, which also extend over two print lines in the Y-direction. One picture area 3 is in this case reproduced by either picture element 4a or picture element 4b. Here also the width or total width of the lines 8 or 8a, 8b corresponds to the desired grey value of the picture area 3. Resolution, however, is reduced compared with the first embodiment due to the larger picture elements 4a, 4b. Dynamics and linearity on the other hand are improved. Overall, twice as many grey values can be set within the picture elements 4a, 4b as in the case of the picture elements shown above them.

Further examples of picture elements 4c, 4d are shown in figure 2 (c), where the picture element 4c contains nine pixels 5 and a line 9 on its left-hand edge, while picture element 4d contains nine pixels 5 and three lines 9a, 9b, 9c, which extend longitudinally or in the Y-direction over three print lines of the laser printer 10. In this case also, a picture area 3 is reproduced by the picture elements 4a or 4d.

Reference will now be made to figures 3 and 4 to explain in more detail how the density of a picture area is set by line broadening. Figure 3 (a) shows a picture element 4e with sixteen pixels 5 for reproduction of a picture area 3 with a density value S, which amounts to about 35% of the total density. By subdividing the width of a pixel 5 into 32 stages, the total density of 100% is obtained after 128 stages, whereas a density of around 35% occurs after only 64 stages (cf. figure 4). With this density of around 35%, picture element 4e is therefore half-filled with a line 11, which extends in the Y-direction over four print lines of the laser printer 10. If the laser beam of the laser printer 10 reaches a picture element 4e along a print line I, the counting value Z of a counter 12 is set initially

to a value corresponding to the desired density S, in conformity with the density pattern shown in figure 4. The counting value Z in this case is therefore 64. The counter 12 in figures 5 and 6 is set so that it reduces the set counting value to zero. While it counts down, it supplies, in conformity with the counting diagram shown in figure 3 (b) a counter output signal D according to figure 3 (c), which controls a laser diode 13 within a printing unit 14 of the laser printer 10. Therefore, while the laser diode 13 is under the control of the counter output signal D, the width of the line 11 in figure 3 (a) is broadened in the printing direction of the line I until the counting value zero is reached. Since there are a total of four pixels 5 in the print line direction, this operation is repeated for four successive print lines I to IV in order to obtain a square picture element 4e. If a broader or narrower line 11 needs to be obtained in conformity with the relevant density value of the picture area 3, the counter 12 is set at the beginning to a correspondingly higher or lower counting value Z.

The size of the smallest picture unit used to produce a digital picture does not therefore correspond to the size of a pixel but rather to the size of a line element within a pixel, the width of which is no more than a fraction of the pixel width. A line with such a small width can be produced, for example, by means of only a minimal deflection of the laser beam.

Figure 5 shows a picture reproduction system according to the invention. This picture reproduction system comprises a conventional computer 15, a data store 16 with the above-mentioned picture store and a text store 17, as well as the aforementioned laser printer 10. The laser printer 10 contains the printing unit 14 with the laser diode 13, a control element 18, a text buffer 19 for one page and a signal generator 20. Text from the text store 17 is fed page by page into the text buffer 19 and via the signal generator 20 to the printing unit 14, so that it can be printed on the picture carrier 7 by means of the laser diode 13, which has an amplifier 21 connected in front of it. The printing operation is carried out under the control of the computer 15 and control element 18, which in turn supplies a line synchronisation signal and a page synchronisation signal to the computer 15 or data store 16.

The picture reproduction system has an additional unit 22, which contains the aforementioned counter 12 for line broadening, a logic OR circuit 23 and two line stores 24, 25. The two line stores 24, 25 (line buffers) are connected on the input side to the picture store 1 and on the output side to the counter 12, the output of which is in turn connected to one input of the OR circuit 23. The other input of the OR circuit 23 is connected to the signal generator 20. The OR circuit 23 is connected on the output side

via the amplifier 21 to the laser diode 13 of the printing unit 14. The line stores 24, 25 also receive the line synchronisation signal and page synchronisation signal from the control element 18 of the laser printer 10.

While text is being printed, the signal generator 20 supplies a text signal Te via the OR circuit 23 and the amplifier 21 to the laser diode 13. As soon as a picture needs to be generated within a text on a page, and this is identified by means of an appropriate marker (control flags in the prepared text), picture element data from the picture store 1 for the next two print lines of the laser printer 10 are stored line by line in the line stores 24 and 25. The picture element data from the line store 24 are transmitted successively to the counter 12, whose counting value Z is reset each time by the successive picture element data along a print line to a value corresponding to the respective data value or density value for a picture element and which supplies a counter output signal D until its counting value Z reaches zero. This counter output signal D is also transmitted via the OR circuit 23 and the amplifier 21 to the laser diode 13 in order to print a picture line on the picture carrier 7. In this way, lines are generated along the picture line within the individual picture elements with a width corresponding to the respective counting value Z of the counter 12. Line width is therefore controlled by the counter output signal D of the counter 12. The text signal Te and counter output signal D can of course also be generated simultaneously so that text can be printed within a picture area.

The counter 12 is always reset (figure 6) when a cycle setting counter 26 has passed through a predetermined number of counting steps, which determines the size of a picture element in the direction of the print line. The picture element cycle P is therefore determined by the cycle setting counter 26. For this purpose, the counting value of the cycle setting counter 26 is set cyclically to a counting value which is supplied to it from an 8-bit register 27. The counting value in the 8-bit register 27 is stored by the computer in conformity with the picture element size. If, for example, the counting value 32 is in conformity with figure 2 (a), the picture element cycle P is the pixel cycle. If the counting value for the cycle setting counter 26 is 64, the picture element cycle P is equal to two pixel cycles and so on. In conformity with the start of a cycle P, a clock signal T is supplied which is dependent on time t and which resets the counter 12 to its counting value Z for the following picture element cycle P. Both counters 26 and 12 operate at the same constant frequency. The counting value of the counter 12 is always equal to or less than the counting value of the counter 26. In conformity with the counting period of the counter 12, the aforementioned counter output signal D is then generated to switch the laser diode 13 of the laser printer 10 on and off,

as shown in figure 6.

It is advantageous for a table store 28, in which is stored the relationship between the grey value determined by the picture element data and the counting value required for production of this grey value, where the counting value Z is supplied to the counter 12 on input of the picture element data into the table store 28, to be arranged between the output of the line stores 24, 25 and the input of the counter 12.

Two line stores 24, 25 are provided owing to the high deflection speed of the laser printer 10. They are connected to the picture store 1 and the counter 12 so that the picture data is always output to the counter 12 from one line store only (e.g. 24), while the other (e.g. 25), independent of the fixed time response of the laser printer 10, can be loaded by the computer 15 with picture element data from the picture store 1. The computer 1 checks which of the line stores 24, 25 is outputting the picture data to the counter 12, and which of the line stores 24, 25 is therefore currently being loaded.

Patent claims

1. Picture reproduction system for producing a digital picture with
- a data store (16) containing a picture store (1) and a text store (17),
- a laser printer (10) for printing out picture element data stored in the picture store (1) and/or text data stored in the text store (17) with the aid of a laser diode (13),
- two line stores (24, 25) for storage of data for two successive lines in the picture,
- a counter (12),
- an OR circuit (23), via the output of which a laser beam emitted by the laser diode (13) is modulated, and
- a computer (15) for operational control,

in which
- the two line stores (24, 25) are connected on the input side to the picture store (1) and on the output side to the counter (12) in order to be loaded alternately with the picture element data and then to supply the latter to the counter (12), when the other line store is being loaded,
- the output of the counter (12) is connected to an input of the OR circuit (23), the other input of which receives a text signal (Te) obtained from the text data from the laser printer (10), and
- the counting value (Z) of the counter (12) for successive picture elements along each line of the picture is reset each time to a value corresponding to the respective grey value for a picture element, so that the counter (12) supplies a counter output signal (D) switching on the laser diode (13) until the counting value (Z) has reached zero.

2. Picture reproduction system according to claim 1, in which the counter (12) is always reset when a cycle setting counter (26) has passed through a predetermined number (P) of counting steps, which determines the size of a picture element in the direction of the picture line.

3. Picture reproduction system according to claim 1 or 2, in which the picture element data of a picture line can be repeatedly read out in conformity with the size of the picture element.

* C L M S *

4. Picture reproduction system according to one of Claims 1 to 3, in which a table store (28), in which is stored the relationship between the grey value determined by the picture element data and the counter value (Z) required for production of this grey value, which is supplied to the counter (12) on input of the picture element data, is arranged between the outputs of the line store (24, 25) and the input of the counter (12).