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(54) **Method and system for providing a colour match between a scanned colour test pattern and the respective printout of a colour printer, using a closed control loop**

Verfahren und Vorrichtung zum Farbabgleich zwischen einem abgetasteten Testbild und dem zugehörigen Ausdruck eines Farbdruckers, mittels einer geschlossenen Regelschleife

Procédé et système pour l'égalisation en couleurs en boucle fermée entre une mire couleur échantillonnée et la sortie correspondante d'une imprimante en couleurs

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(56) References cited:
EP-A- 0 144 188
US-A- 4 477 833
US-A- 4 710 785
US-A- 4 839 722

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Description

Technical Field

This invention relates generally to color correction techniques used in digital color printing and more particularly to improving the color print quality of color printers and color copiers. The present invention provides a method and means for continuously matching the color output of a color printer with the color of an image read by a scanner which feeds the printer.

Background Art

In the fields of color copying and color printing, it is known to convert red, blue, and green (R,B,G) output data from a scanner into corresponding cyan, yellow, magenta and black (C,Y,M,K) data and then to further process and refine this C,Y,M,K data before using same to drive a color printer. One such conversion system is described, for example, in U.S. patent US-A-4,930,018 of C. S. Chan et al entitled "Method and System For Enhancing the Quality of Both Color and Black and White Images Produced by Ink Jet Printers", assigned to the present assignee (European Application No. 89312460.2 published under EP-A-0 372 826). Other related types of color conversion systems are disclosed in Clark et al U.S. Patent US-A-4,477,833, Yoshida et al U.S. Patent US-A-4,719,490, and Myers U.S. Patent US-A-4,751,535.

Using the color conversion technique described and claimed in the above-mentioned US-A-4 930 018, it becomes necessary to employ a large and complete color gamut in order to generate a data bank or memory known as a "look up table" or LUT. This look up table is in turn stored in the memory of a computer and then used by the computer for converting the received red, blue, and green data to cyan, magenta, yellow, and black data which is in turn used to drive a color printer. This complete color gamut should be prepared on the same type of print media and using the same type of ink, pen, drop volume and dye loading as is expected to be used by the color printer or copier under control of an image scanner. This operation is necessary in order to provide the best possible color match between the hardcopy output of the colour printer and the scanned color image which is converted to C,Y,M & K data for driving the color printer. A color mismatch or color distortion will occur between the colors in the scanned image and the colors in the hardcopy output of the color printer when there is a change over time in any one of the above original parameters of print media, ink, dye, pen type, or drop volume. Furthermore, the above color mismatch or distortion will also be caused by changes in calibration which may occur over time to the separate calibration systems which are, respectively, part of the image scanner and a densitometer which is used to convert the color gamut into its R,G, & B components.

One solution to the above problem of color mismatch is to continuously update the full color gamut every time there is a change in one of the above five print parameters or in the calibrations of the scanner and densitometer. However, such a continuous updating of the large scale color gamut is very expensive and time consuming for reasons described in more detail below.

EP-A-0 144 188 discloses a process for automatically correcting the tone and color reproduction characteristics of a color reproduction system is described. First, a test target containing a plurality of color patches of known or desired chromaticity coordinates and luminance is copied. Each patch on the copy is then analyzed by a colorimeter to generate sets of chromaticity coordinates for each patch. These are compared against the desired chromaticity coordinates for each color patch, and a set of tone reproduction corrections are generated and stored in a look-up table for each colorant in the color reproduction system.

US-A-4 710 785 discloses an electrostatographic machine with at least one adjustable process control parameter. The machine receives and electronically stores electrical image information signals of an original. A reproduction of the original is created using the received electrical image information signal, and a second electrical image information signal is in turn created from the reproduction. The second electrical image information signal is compared with the first electrical image information signal to produce an error signal representative of differences therebetween. The process control parameter is adjusted in response to the error signal to minimize said differences.

Features of the invention are described in Claims 1 and 3.

An object of the invention is to provide an improved and relatively inexpensive method and system for providing good color match between the image read by a color scanner and the hardcopy output of a color printer or copier controlled thereby.

Another object is to provide a new and improved method and system of the type described which does not require continuous updating of a large color gamut and the computational expenses associated therewith.

Another object of this invention is to provide a new and improved method and system of the type described which is readily adaptable to incorporation into existing color copiers and printers and which may be used with various types of printers such as thermal ink jet printers, thermal printers, electrostatic printers and the like.

These and other objects and attendant advantages of this invention are accomplished by the provision of a method and system of color correction wherein initially a large color gamut is prepared and utilized to generate an initial look up table for storage into the memory of a computer. This look up table is based upon a preselected print medium, ink, dye loading, pen type, and drop volume. A pre-generated test pattern, TP_{in}, derived from a small chosen color gamut is then fed through a scan-

ner which is operative to generate R,G,B output data. This R,G,B output data is in turn fed to the above computer where the above look up table converts it to C,Y, M,K data and processes this C,Y,M,K data to a color printer using standard error diffusion and pixel assignment procedures such as those described in my above identified copending application or other order dither methods. The output data of the color printer is designated as TP_{out}, and this output test pattern TP_{out} is fed back to the scanner to generate another set of R,G,B data. Then, using standard mathematical conversion procedures, a conversion factor, H, is obtained in accordance with the relationship:

$$\text{Equation 1: } TP_{in} = H \cdot TP_{out}$$

where H is a matrix mapping function used for mapping TP_{out} to TP_{in}.

The sequence of steps of this novel method embodying the invention includes providing a full scale color gamut based upon preselected parameters such as print media, inks, dyes, drop volumes and pen types; constructing an initial look up table based upon this full scale color gamut; storing this initial look up table in a computer, comparing a sample test pattern of input information, TP_{in}, read from a small color gamut or "patch" by a color image scanner with a test pattern of output information, TP_{out}, generated by a color printer; generating a corresponding correction factor, H, as defined by Equation 1 above; and then using this correction factor H to update the initial look up table which is stored in a computer memory. In this manner, the color differences between the image scanned by the image scanner and the hardcopy output of a color printer are always minimized.

The above objects and other advantages and unique features of this invention will become better understood with the reference to the following description of the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a functional block diagram of one type of image conversion system in which the present invention may be incorporated.

Fig. 2 is a flow chart depicting the data processing methodology for practicing the present invention.

Fig. 3 is a functional block diagram corresponding to steps 20,22,24,26 and 28 in Fig. 2.

Fig. 4 functionally illustrates a data processing system for carrying out the steps of Fig. 1 and which can be implemented by those skilled in the art using existing off-the-shelf electronic products commercially-available in the image processing and printer fields of technology.

Figs. 5 and 6 are large and small color gamuts, respectively, which are typical of those useful in practicing the invention.

Description of the Preferred Embodiment

Referring now to Fig. 1, the image conversion system shown herein is of the type described in my above copending application serial no. 278,881 and is just one type of system with which the present invention may be used. In this system in Fig. 1 a scanner 10 is used to convert a color image into digital gray scale data for application to an additive red-green-blue (R-G-B) format conversion stage 12. The R-G-B output data from the format conversion stage 12 is applied as indicated to the subtractive color primaries cyan-yellow-magenta (C-Y-M) color conversion stage 14 in a well known manner and including 100% undercolor removal to obtain black. Achromatic color (black) cannot be easily made by mixing Y-M-C ink colors, and such mixing will increase the amount of ink consumed. Therefore, the black created by Y,M,C colors is preferably replaced by pure black (K). This replacement and the generation of pure black is known in the art as undercolor removal (UCR). The use of 100% undercolor removal is for the purpose of minimizing ink consumption and to improve resolution. The equation for 100% UCR for colors C, M, Y and K is K = min (C, M, Y) where the new C = C-K, the new M = M-K and the new Y = Y-K.

The output of the C-Y-M color conversion stage 14 is a digital data stream which is applied to the error diffusion and pixel assignment stage 16, and the latter stage 16 in turn drives a color printer 18, preferably a thermal ink jet color printer. The general functional arrangement of the image scanning and color reproduction system of Fig. 1 is well known in the image processing art. The image processing operation and capability of such a system is described, for example, in the March 1987 issue of BYTE Magazine in an article by B. M. Dawson entitled "Introduction To Image Processing Algorithms" at page 169 et seq. Such image processing capability and corresponding system operation is also described in a publication by Gary Dispoto et al entitled Designer's Guide to Raster Image Printer Algorithms, First Edition, December 1986, copyrighted by and available from the Hewlett-Packard Company in Palo Alto, California.

The processes of error diffusion and pixel assignment in stage 16 of Fig. 1 in a gray scaling image processing operation are also generally well known in this art. Error diffusion is a technique used to disperse to the neighboring pixels the error between a printable gray scale and the input image gray scale data. This error diffusion has been frequently carried out using a selected one of many well known algorithms such as those discussed in the above identified Dawson article. As an example, this error diffusion may be carried our using either one of two well known algorithms in this art, namely, Floyd and Steinberg's 4-point algorithm and Stucki's 12-point algorithm.

Referring now to Fig. 2, this figure will be described in terms of sequential signal processing steps, including

providing a complete color gamut at step 20, and this color gamut may consist typically of up to 200 color patches arranged in an X-Y matrix. This complete color gamut is shown in Fig. 5 herein and is read by a densitometer at step 22 to in turn generate filtered red, green, and blue data at step 24. This data from step 24 is then programmed at step 26 into either a separate computer or a computer located within a color printer where it is used to generate a look up table at step 28. A comprehensive color gamut is required here to adequately cover the entire color space when generating the initial look-up table for storage into computer memory.

A simplified test pattern such as the one shown in Fig. 6 herein is provided as indicated at step 30 and may include, for example, a 4x6 matrix of R,G,B patches and C,Y,M patches arranged in adjacent rows and columns. The simplified test pattern ("patch") provided in step 30 is scanned using a conventional color scanner at step 32 to in turn generate R,G,B input test pattern (TP_{in}) data for application to a computer. The TP_{in} data from step 32 is then processed through the initial look up table previously stored in a computer memory to generate corresponding C,M,Y and K output data as indicated at step 34. The C,M,Y and K data in step 34 is related to the R, G,B data by a first transformation matrix or conversion factor, F, and the data from step 34 is applied to a color printer to generate output test pattern data, TP_{out}, at step 36. The test pattern output data TP_{out} at step 36 is then fed back to the same scanner that is used in step 32 above and is further used in step 38 to generate corresponding output R,G,B data from the color scanner and representative of TP_{out}. The TP_{out} data from the color scanner in step 38 is then applied to the computer at step 40 where TP_{out} R,G,B data is compared therein to TP_{in} R,G,B data to in turn generate a compensation matrix H. This compensation matrix is also referred to herein as a second transformation matrix or second conversion factor, H, and is defined in Equation 1. above.

The second transformation matrix, H, is then mathematically merged in step 42 with the previously identified first transformation matrix or conversion factor F to generate a new updated color look up table to be stored in either a separate computer or a computer which is located in a color printer or color copier.

The computational effort, e.g. time, for generating the first transformation matrix or conversion factor, F, used to obtain the above R,G & B components for the initial look up table depends upon the dimensions of the full scale color gamut in Fig. 5. To a first order approximation, this computational effort is proportional to N^3, where N is the number of patches in the color gamut. For example, in generating the conversion factor F for a 20x20 patch matrix, N will be 20x20 or 400 and N^3 will equal 64 X 10^6 floating point operations. However, in generating the second transformation matrix, H, the dimension of the input vector N is 24 for 6X4 color patches; hence N^3 = 13,824 floating point operations. In the above example, not only is there provided a substantial saving in computational cost, but in addition a significant amount of time is saved in preparing the color gamut input data TP_{in}. This updating procedure continuously corrects for the drifting in the calibration of the equipment used as well as changes in the parameters of ink, pen, paper, drop volume, dye loading or other similar parameters that may change over time. The use of the smaller 4X6 color gamut (Fig. 6) is sufficient for use in the updating process inasmuch as most of the correct color information is already present in the then-existing color look up table, and only minor color corrections are needed. Furthermore, all of the major colors of the full color gamut color space are present in the 4X6 color patch matrix in Fig. 6 and are quite sufficient for use in the present continuous updating error correction process and provide excellent scanned image-to-hardcopy output color match.

Referring now to Fig. 3 which shows the functional relationship between the complete color gamut, densitometer and memory for storing the initial LUT, a complete color gamut 44 is read by a densitometer 46 to convert the cyan, magenta and yellow information of all of the pixels of the color gamut to red, green and blue information. The mathematical relationship of mapping the RGB information into CMY information is shown in stage 48, and this mapping function is stored in the computer memory of stage 52 as a look up table.

Referring now to Fig. 4, as previously indicated, a color image scanner 54 is positioned and connected to receive red, green & blue data at a first input line 56 from a small simplified test pattern 58 consisting, for example, of a 6X4 matrix of R,G,B patches and C,Y,M,K patches arranged in adjacent rows and columns and shown in Fig. 6 hereof. The simplified test pattern or patch 58 is scanned by the scanner 54 to generate R, G,B input test pattern data, or TP_{in} data, on the output 60 and applied to the memory stage 52 in the computer 62. This R,G,B data labeled TP_{in} is also applied by way of line 64 to one input connection of a transformation or conversion algorithm stage 66.

The color scanner 54 receives the output test pattern, TP_{out}, in the feedback path 68 from the output of the color printer 70 and which is shown as a second input line feeding the scanner 54.

The memory stage 52 corresponds to the same numbered stage in Fig. 3 and is part of either a general purpose or special purpose computer 62 which also includes an updated look up table 72. The output of the LUT 72 is connected to an error diffusion or order dither stage 74, and the output line 76 of stage 74 is connected to drive the color printer 70. The color printer 70 may, for example, include an input pixel assignment stage 78 which drives a nozzle firing stage 80 operative for generating the output test pattern, TP_{out}.

The color scanner 54 scans the output test pattern TP_{out} for determining color variations therein and in turn generates respective TP_{out} data on line 82 which is applied as a second input signal to the transformation al-

gorithm stage 66. The transformation algorithm in stage 66 is used to thus update the first conversion factor F (generated from the initial look up table) by providing the second conversion factor, H. Thus, F_{old} is updated in stage 84 to F_{new} by the relationship $F_{new} = H \cdot F_{old}$. The updated new conversion factor, F_{new}, as indicated at the output of stage 84 is provided as input data to an updated color look up table in stage 86, where stages 66, 84 and 86 are all part of a second general purpose or special purpose computer 88. The output signal on line 90 from the updated color look up table in stage 86 is thus applied as an input signal to a storage or memory device 92 as indicated in Fig. 4 and is used to match the color of the hardcopy output with the color of the scanned image input to the color scanner 54. The storage device 92 can be the same as the memory stage 52.

The factors F & H are matrix quantities defined by a plurality of polynomials representative of C, Y and M data within each scanned pixel of a color gamut. These matrix quantities are used to map the R,G,B density information into the C,M,Y color space, and are described in some detail in a paper by F.R. Clapper entitled "An Empirical Determination of Halftone Color-Reproduction Requirements", Technical Association of the Graphics Arts, Thirteenth Annual Meeting, June 12-14, 1961, pp. 31-41. Clapper describes how to map the R,G,B density information into the C,M,Y color space by the construction of either a set of linear or polynomial equations and by solving the coefficients thereof explicitly. However, this approach has the limitation that the number of equations and the number of coefficients (either linear or polynomial) must be matched. Hence, for a large number of color patches, this process will generate an unrealistically high order of equations, and the solution of the coefficients thereof may be very sensitive to the color patches being chosen.

Therefore, in accordance with the present invention, all of these equations were cast into a "least square error" problem whose advantage is that it is not now necessary to match the number of unknown polynomial coefficients with the number of equations which are a function of the number of color patches scanned. Thus, we are now free to choose the type of mapping relationship to be used, and this least square solution is accomplished as indicated below:

The outline of obtaining H in equation (1) is as follows: Given TP_{in}, TP_{out} and the functional relationship for H, the task is to obtain a value for H such that the overall sum of squares of the error is minimized:

$$\text{Minimize } \Sigma\, e_i^2 = e^T e$$

$$= (TP_{in} - H \cdot TP_{out})^T (TP_{in} - H \cdot TP_{out})$$

This approach is known in the art as the least square minimization process, and is described, for example, in a well known classical textbook authored by Richard Bellman and entitled Introduction To Matrix Analysis, McGraw Hill Book Company Inc. 1960.

Various modifications may be made in the above-described embodiment without departing from the scope of this invention. For example, it is not necessary that the computers represented as 62 and 88 in Fig. 4 be separate computers and instead these units 62 and 88 may both be part of single more complex computer.

Claims

1. A method for matching the color of an image read by a color image scanner (10) to a printed hardcopy output of a color copier or printer (18) which is controlled by image data output from the scanner (10), the method comprising the steps of:

   a. providing a full scale color gamut (20,44) having a first number of color patches, said color gamut (20,44) being prepared on the basis of preselected parameters including type of print medium, type of ink, pen, drop volume and dye loading as is expected to be used by said color copier or printer (18),

   b. constructing (28) an initial look-up table (F) by (i) reading said full scale color gamut (20,44) to provide RGB data, (ii) mapping (48) said RGB data into CMY information, and (iii) storing said initial look-up table (F) in a memory (52),

   c. scanning (32) a sample test pattern (TP_{in}), having a second number of colour patches smaller than said first number, to provide first input scanned image data and generating therefrom an output test pattern (TP_{out}) with said colour copier or printer (18) and by using (34) said look-up table (F), and scanning (38) said output test pattern (TP_{out}) to provide second input scanned image data, and

   d. comparing (40) said first and second scanned image data so as to generate a transformation matrix (H) and merging said look-up table (F) with said transformation matrix (H) to generate an updated version of said look-up table, such that the colour differences between the image scanned by said colour scanner (10) and the hard-copy output, generated by using said look-up table (F), are reduced.

2. The method defined in Claim 1 wherein merging of the look-up table (F) and the matrix (H) is effected by multiplication.

3. A system for continuously matching the color of an image read by a color image scanner (10) to a printed hardcopy output of a color copier or printer (18) which is controlled by image data output from the

scanner (10), the system comprising:

a. color gamut means (20,44) for providing a full scale color gamut (Fig. 5) having a first number of color patches, said color gamut (20,44) being prepared on the basis of preselected parameters including type of print medium, type of ink, pen, drop volume and dye loading as is expected to be used by said color copier or printer (18),

b. means (54,62) for reading (22) said color gamut means (20) for constructing an initial look-up table (F) based upon reading of said full scale color gamut (20,44) to provide RGB data, mapping said RGB data into CMY information and storing said initial look-up table (F) in a memory (52),

c. scanning means (54) for scanning a sample test pattern (TP_{in}), having a second number of colour patches smaller than said first number, to provide first input scanned image data and generating therefrom an output test pattern (TP_{out}) with said colour copier or printer (18) and by using (34) said look-up table (F), and scanning (38) said output test pattern (TP_{out}) to provide second input scanned image data, and

d. means (88) for comparing (40) said first and second scanned image data so as to generate a transformation matrix (H) and for merging said look-up table (F) with said transformation matrix (H) to generate an updated version of said look-up table, such that the colour differences between the image scanned by said colour scanner (10) and the hard-copy output, generated by using said look-up table (F), are reduced.

4. The system defined in Claim 3 which includes:

computer means (62,88) connected to said colour scanning means (54) to receive said input scanned image (TP_{in}) and to utilise said initial look-up table (F) in said memory (52) to convert said data derived from said input scanned image (TP_{in}) and to revise said initial look-up table (F); said computer means (62) controlling production of said output test pattern (TP_{out}) to be fed back from said printer (18) to said colour scanning means (54).

Patentansprüche

1. Ein Verfahren zum Herstellen einer Übereinstimmung der Farbe eines Bildes, das von einem Farbbildabtastgerät (10) gelesen worden ist, und einer gedruckten Druckkopieausgabe eines Farbkopierers oder -Druckers (18), welcher durch eine Bilddatenausgabe von dem Abtastgerät (10) gesteuert wird, wobei das Verfahren folgende Schritte aufweist:

a. Schaffen einer Vollbereich-Farbskala (20, 44) mit einer ersten Anzahl von Farbausschnitten, wobei die Farbskala (20, 44) auf der Basis vorgewählter Parameter, einschließlich des Typs des Druckmediums, des Tintentyps, des Stifts, des Tropfenvolumens und der Farbladung, vorbereitet worden ist, wie sie erwartungsgemäß von dem Farbkopierer oder dem Farbdrucker (18) verwendet werden;

b. Aufbauen (28) einer anfänglichen Direktzugriffstabelle (F) durch (i) Lesen der Vollbereich-Farbskala (20, 44), um RGB-Daten zu schaffen, (ii) Abbilden (48) der RGB-Daten in CMY-Informationen, und (iii) Speichern der anfänglichen Direktzugriffstabelle (F) in einem Speicher (52);

c. Abtasten (32) eines Probentestmusters (TP_{in}) mit einer zweiten Anzahl von Farbausschnitten, die kleiner als die erste Anzahl ist, um erste Eingabe-Abtastbilddaten zu schaffen, und um aus denselben ein Ausgabetestmuster (TP_{out}) mit dem Farbkopierer oder -Drucker (18) und unter Verwendung (34) der Direktzugriffstabelle (F) zu erzeugen, und Abtasten (38) des Ausgabetestmusters (TP_{out}), um zweite Eingabe-Abtastbilddaten zu schaffen; und

d. Vergleichen (40) der ersten und zweiten Abtastbilddaten, um eine Transformationsmatrix (H) zu erzeugen, und Verschmelzen der Direktzugriffstabelle (F) mit der Transformationsmatrix (H), um eine aktualisierte Version der Direktzugriffstabelle zu erzeugen, derart, daß die Farbunterschiede zwischen dem Bild, das von dem Farbabtastgerät (10) abgetastet worden ist, und der Druckkopieausgabe, die unter Verwendung der Direktzugriffstabelle (F) erzeugt worden ist, reduziert werden.

2. Das Verfahren gemäß Anspruch 1, bei dem das Verschmelzen der Direktzugriffstabelle (F) und der Matrix (H) durch Multiplikation bewirkt wird.

3. Ein System zum durchgehenden Herstellen einer Übereinstimmung der Farbe eines Bildes, das von einem Farbbildabtastgerät (10) gelesen worden ist, und einer gedruckten Druckkopieausgabe eines Farbkopierers oder -Druckers (18), welcher durch eine Bilddatenausgabe von dem Abtastgerät (10)

gesteuert wird, mit folgenden Merkmalen:

a. einer Farbskalaeinrichtung (20, 44) zum Schaffen einer Vollbereich-Farbskala (Fig. 5) mit einer ersten Anzahl von Farbausschnitten, wobei die Farbskala (20, 44) auf der Basis vorgewählter Parameter einschließlich des Typs des Druckmediums, des Typs der Tinte, des Stifts, des Tropfenvolumens und der Farbladung vorbereitet worden ist, wie sie erwartungsgemäß von dem Farbkopierer oder -Drukker (18) verwendet werden;

b. einer Einrichtung (54, 62) zum Lesen (22) der Farbskalaeinrichtung (20) zum Aufbauen einer anfänglichen Direktzugriffstabelle (F) basierend auf dem Lesen der Vollbereich-Farbskala (20, 44), um RGB-Daten zu schaffen, zum Abbilden der RGB-Daten in CMY-Informationen und zum Speichern der anfänglichen Direktzugriffstabelle (F) in einem Speicher (52);

c. einer Abtasteinrichtung (54) zum Abtasten eines Probentestmusters (TP_{in}) mit einer zweiten Anzahl von Farbausschnitten, die kleiner als die erste Anzahl ist, um erste Eingabe-Abtastbilddaten zu schaffen und um aus denselben ein Ausgabetestmuster (TP_{out}) mit dem Farbkopierer oder -Drucker (18) und unter Verwendung (34) der Direktzugriffstabelle (F) zu erzeugen, und zum Abtasten (38) des Ausgabetestmusters (TP_{out}), um zweite Eingabe-Abtastbilddaten zu schaffen; und

d. einer Einrichtung (88) zum Vergleichen (40) der ersten und zweiten Abtastbilddaten, um eine Transformationsmatrix (H) zu erzeugen, und zum Verschmelzen der Direktzugriffstabelle (F) mit der Transformationsmatrix (H), um eine aktualisierte Version der Direktzugriffstabelle zu erzeugen, derart, daß die Farbunterschiede zwischen dem Bild, das von dem Farbabtastgerät (10) abgetastet worden ist, und der Druckkopieausgabe, die unter Verwendung der Direktzugriffstabelle (F) erzeugt worden ist, reduziert sind.

4. Das System gemäß Anspruch 3, welches folgendes Merkmal aufweist:

eine Computereinrichtung (62, 88), die mit der Farbabtasteinrichtung (54) verbunden ist, um das Eingabe-Abtastbild (TP_{in}) zu empfangen, und um die anfängliche Direktzugriffstabelle (F) in dem Speicher (52) zu verwenden, um die Daten, die von dem Eingabe-Abtastbild (TP_{in}) abgeleitet worden sind, umzuwandeln, und um die anfängliche Direktzugriffstabelle (F) zu überarbeiten; wobei die Computereinrichtung (62) das Erzeugen des Ausgabetestmusters (TP_{out}) steuert, das von dem Drucker (18) zu der Farbabtasteinrichtung (54) rückgekoppelt werden soll.

Revendications

1. Procédé pour faire correspondre la couleur d'une image lue par un dispositif d'analyse optique d'image en couleur (10) avec une sortie imprimée sur papier d'un appareil à copier en couleur ou imprimante (18) qui est commandé par une sortie de données d'image du dispositif d'analyse optique (10), le procédé comprenant les étapes consistant à :

a) fournir une gamme de couleurs de pleine échelle (20, 44) ayant un premier nombre de taches de couleur, ladite gamme de couleurs (20, 44) étant préparée en fonction de paramètres présélectionnés incluant le type de support d'impression, le type d'encre, la plume, le volume de goutte et le chargement des colorants, selon l'utilisation projetée par ledit appareil à copier en couleur ou imprimante (18),
b) construire (28) un tableau de consultation initial (F) en (i) lisant ladite gamme de couleurs de pleine échelle (20, 44) pour fournir des données de couleurs rouge-verte-bleue RVB, en (ii) mettant en correspondance (48) lesdites données RVB avec des informations de chrominance-luminance CMY, et en (iii) mémorisant ledit tableau de consultation initial (F) dans une mémoire (52),
c) analyser optiquement (32) un motif échantillon de test (TP_{in}), ayant un second nombre de taches de couleur inférieur audit premier nombre, pour fournir des premières données d'entrée d'image analysée optiquement et produire à partir de celles-ci un motif de test de sortie (TP_{out}) avec ledit appareil à copier en couleur ou imprimante (18) et en utilisant (34) ledit tableau de consultation (F), et analyser optiquement (38) ledit motif de test de sortie (TP_{out}) pour fournir des secondes données d'entrée d'image analysée optiquement, et
d) comparer (40) lesdites premières et secondes données d'images analysées optiquement de façon à produire une matrice de transformation (H) et fusionner ledit tableau de consultation (F) avec ladite matrice de transformation (H) pour produire une version actualisée dudit tableau de consultation, de telle manière que les différences de couleur entre l'image analysée optiquement par ledit dispositif d'analyse optique en couleur (10) et ladite sortie imprimée sur papier, produite en utilisant ledit tableau de

consultation (F), sont réduites.

2. Procédé selon la revendication 1, dans lequel le fusionnement du tableau de consultation (F) et de la matrice (H) est effectué par multiplication.

3. Système pour faire correspondre de manière continue la couleur d'une image lue par un dispositif d'analyse optique d'image en couleur (10) avec une sortie imprimée sur papier d'un appareil à copier en couleur ou imprimante (18) qui est commandé par une sortie de données d'image du dispositif d'analyse optique (10), le système comprenant:

a) des moyens de gamme de couleurs (74, 44) pour fournir une gamme de couleurs de pleine échelle (Fig.5) ayant un premier nombre de taches de couleur, ladite gamme de couleurs (20, 44) étant préparée en fonction de paramètres présélectionnés incluant le type de support d'impression, le type d'encre, la plume, le volume de goutte et le chargement des colorants, selon l'utilisation projetée par ledit appareil à copier en couleur ou imprimante (18),
b) des moyens (54, 62) pour lire (22) lesdits moyens de gamme de couleurs (20) afin de construire un tableau de consultation initial (F) en se basant sur la lecture de ladite gamme de couleurs de pleine échelle (20, 44) pour fournir des données de couleurs rouge-verte-bleue RVB, la mise en correspondance lesdites données RVB avec des informations de chrominance-luminance CMY, et la mémorisation dudit tableau de consultation initial (F) dans une mémoire (52),
c) des moyens d'analyse optique (54) pour analyser optiquement un motif échantillon de test (TP_{in}), ayant un second nombre de taches de couleur inférieur audit premier nombre, afin de fournir des premières données d'entrée d'image analysée optiquement et produire à partir de celles-ci un motif de test de sortie (TP_{out}) avec ledit appareil à copier en couleur ou imprimante (18) et en utilisant (34) ledit tableau de consultation (F), et analyser optiquement (38) ledit motif de test de sortie (TP_{out}) afin de fournir des secondes données d'entrée d'image analysée optiquement, et
d) des moyens (88) pour comparer (40) lesdites premières et secondes données d'images analysées optiquement de façon à produire une matrice de transformation (H) et fusionner ledit tableau de consultation (F) avec ladite matrice de transformation (H) pour produire une version actualisée dudit tableau de consultation, de telle manière que les différences de couleur entre l'image analysée optiquement par ledit dispositif d'analyse optique en couleur (10) et ladite sortie imprimée sur papier, produite en utilisant ledit tableau de consultation (F), sont réduites.

4. Système selon la revendication 3, comprenant:

des moyens informatiques (62, 88) connectés auxdits moyens d'analyse optique en couleur (54) pour recevoir ladite image d'entrée analysée optiquement (TP_{in}) et pour utiliser ledit tableau de consultation initial (F) dans ladite mémoire (52) afin de convertir lesdites données déduites à partir de ladite image d'entrée analysée optiquement (TP_{in}) et de réviser ledit tableau de consultation initial (F), lesdits moyens informatiques (62) commandant la production dudit motif de test de sortie (TP_{out}) devant être fourni en retour par ladite imprimante (18) auxdits moyens d'analyse optique en couleur (54).

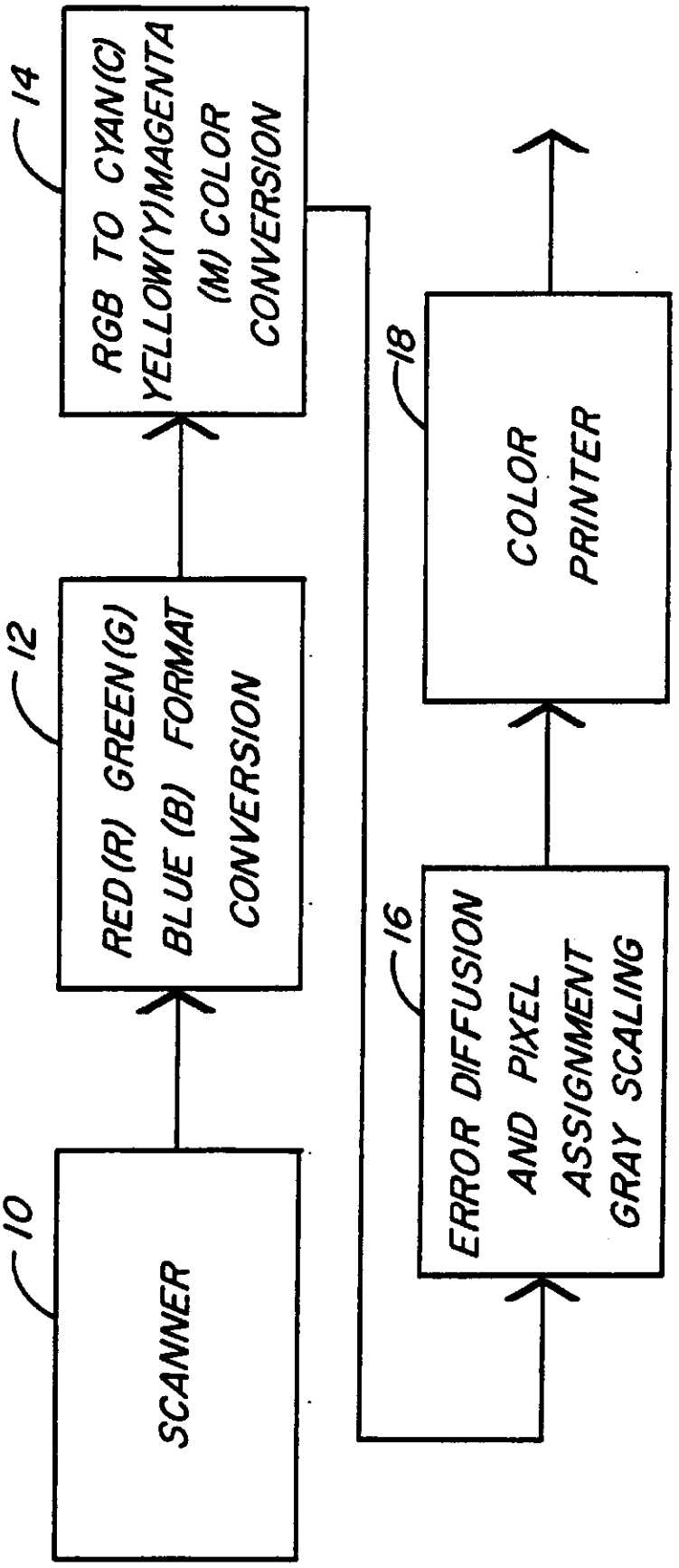

10
SCANNER
12
RED(R) GREEN(G) BLUE (B) FORMAT CONVERSION
14
RGB TO CYAN(C) YELLOW(Y)MAGENTA (M) COLOR CONVERSION
16
ERROR DIFFUSION AND PIXEL ASSIGNMENT GRAY SCALING
18
COLOR PRINTER

Fig. 1

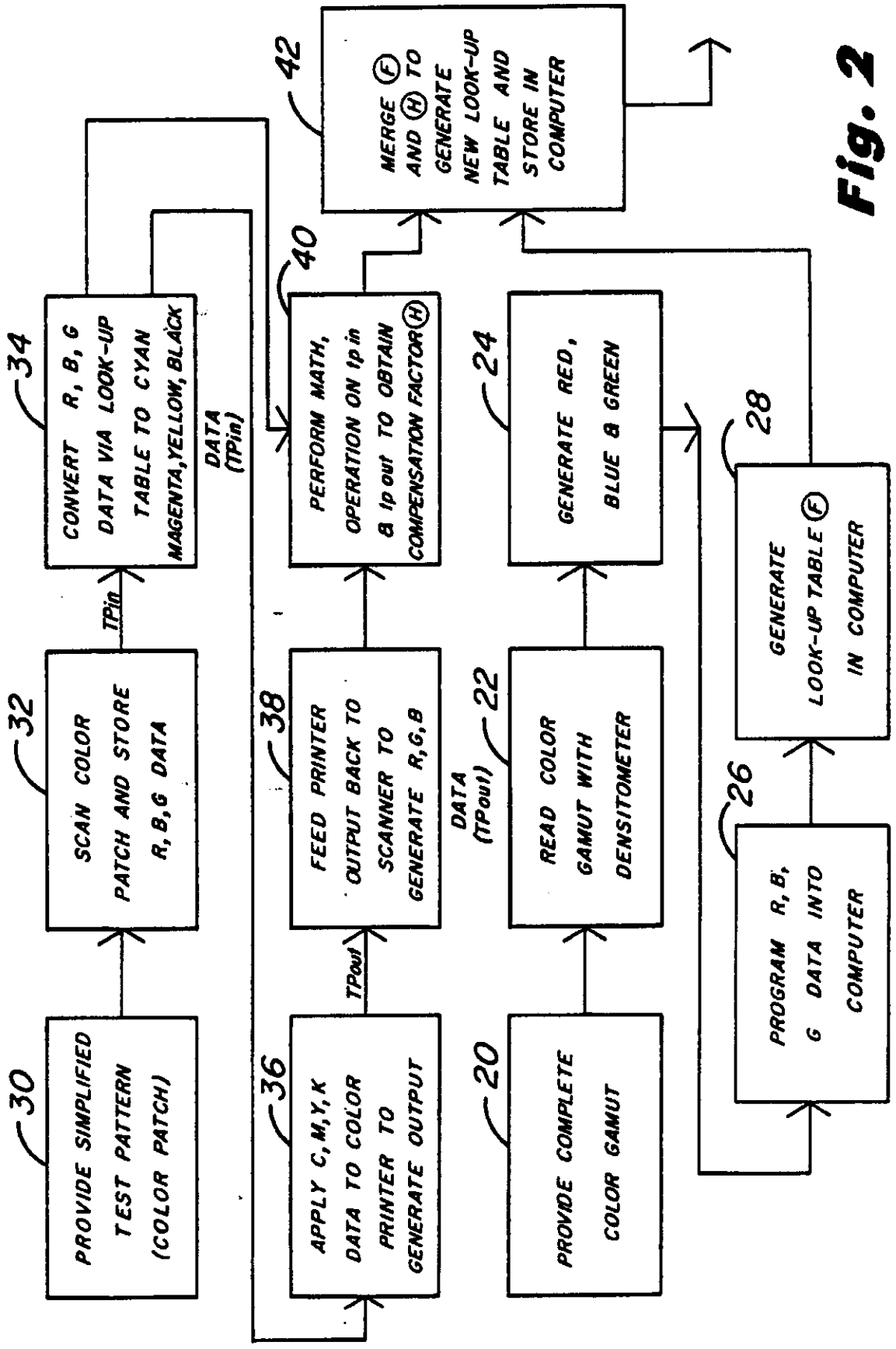

30
PROVIDE SIMPLIFIED TEST PATTERN (COLOR PATCH)
32
SCAN COLOR PATCH AND STORE R, B, G DATA
34
CONVERT R, B, G DATA VIA LOOK-UP TABLE TO CYAN MAGENTA, YELLOW, BLACK
TPin
DATA (TPin)
36
APPLY C, M, Y, K DATA TO COLOR PRINTER TO GENERATE OUTPUT
TPout
38
FEED PRINTER OUTPUT BACK TO SCANNER TO GENERATE R, G, B
40
PERFORM MATH, OPERATION ON Ip in & Ip out TO OBTAIN COMPENSATION FACTOR Ⓗ
42
MERGE Ⓕ AND Ⓗ TO GENERATE NEW LOOK-UP TABLE AND STORE IN COMPUTER
20
PROVIDE COMPLETE COLOR GAMUT
DATA (TPout)
22
READ COLOR GAMUT WITH DENSITOMETER
24
GENERATE RED, BLUE & GREEN
26
PROGRAM R, B, G DATA INTO COMPUTER
28
GENERATE LOOK-UP TABLE Ⓕ IN COMPUTER

Fig. 2

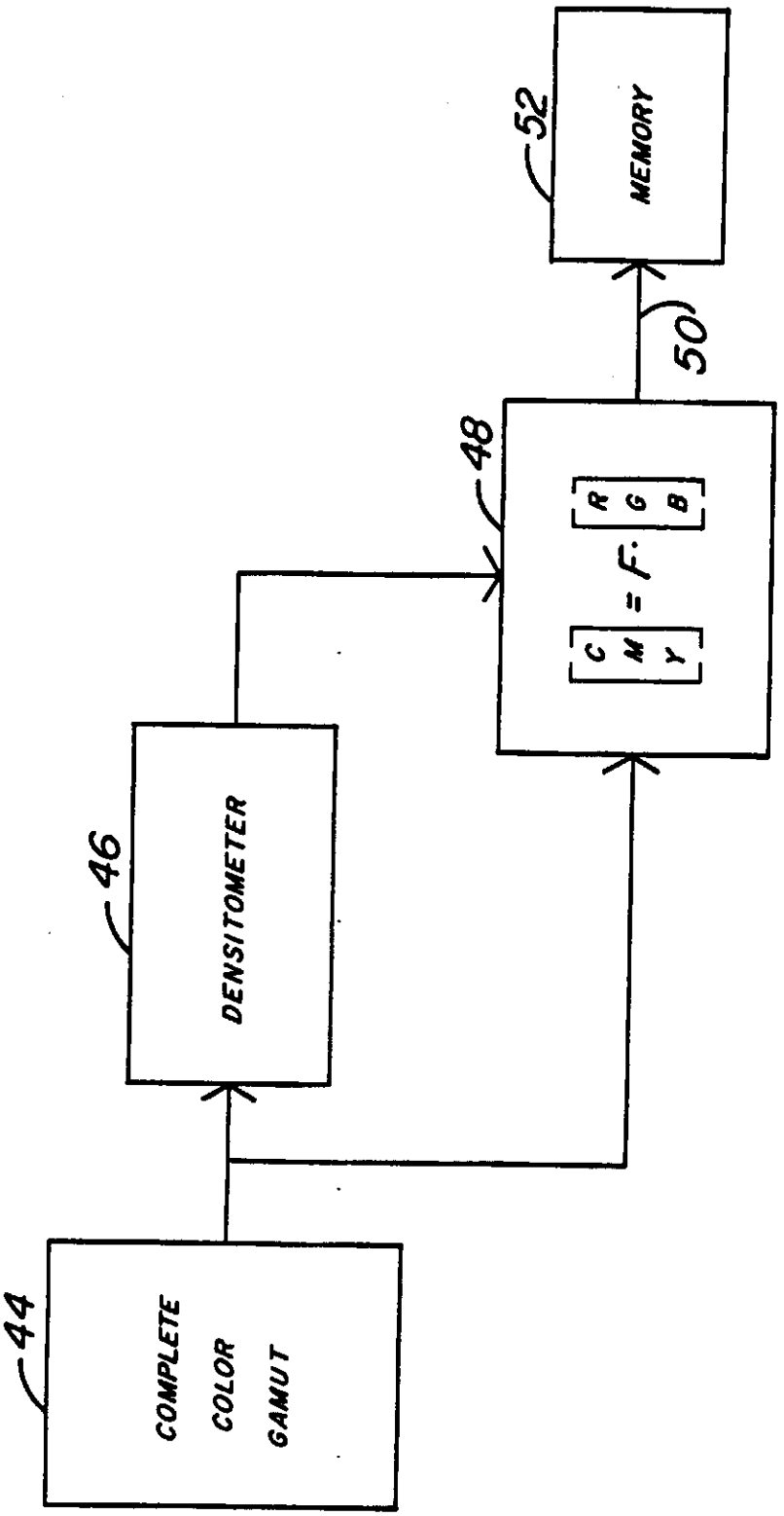

44
COMPLETE COLOR GAMUT
46
DENSITOMETER
48
C M Y = F · R G B
50
52
MEMORY

Fig. 3

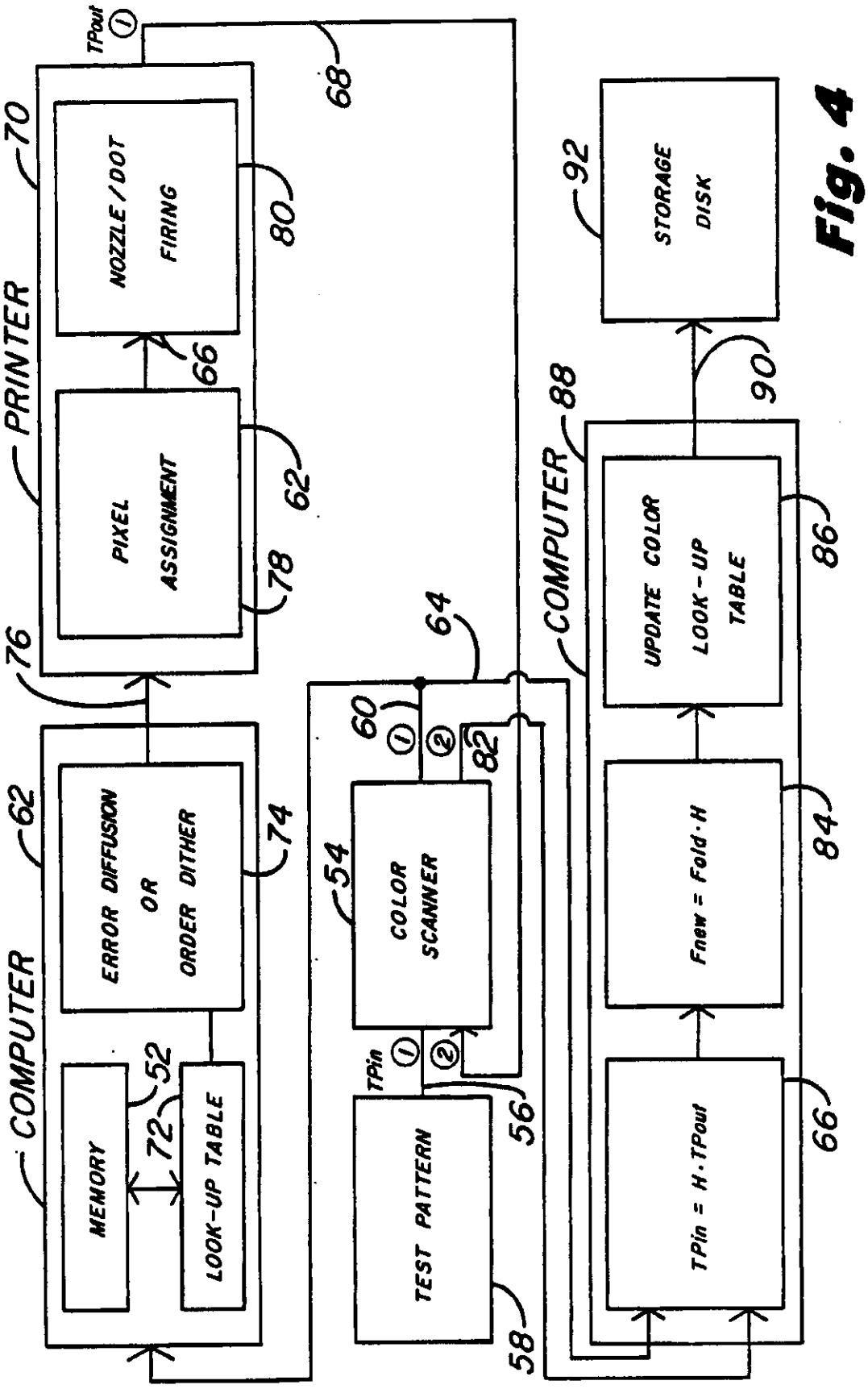

TPout
68
70
PRINTER
NOZZLE / DOT FIRING
80
66
PIXEL ASSIGNMENT
62
78
76
64
COMPUTER
62
ERROR DIFFUSION OR ORDER DITHER
74
MEMORY
52
72
LOOK-UP TABLE
60
82
54
COLOR SCANNER
TPin
56
TEST PATTERN
58
COMPUTER
88
UPDATE COLOR LOOK-UP TABLE
86
Fnew = Fold · H
84
TPin = H · TPout
66
92
STORAGE DISK
90

Fig. 4



Fig. 5

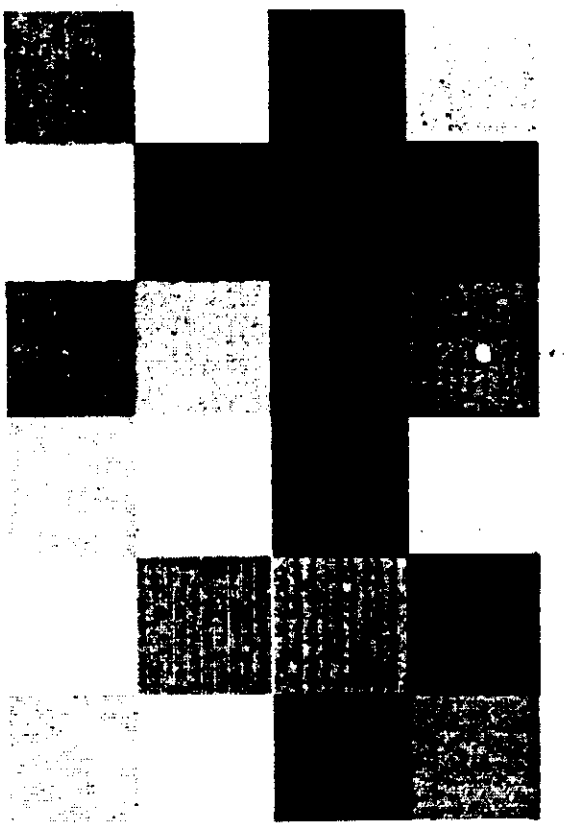


Fig. 6

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02.12.1991 EPO: Search report published on 02.01.1992
Entry Type 25.11 Staff ID. RD06 Auth ID. EPT

17.05.1996 Title truncated for publication date 19.06.1996 by UK Patent Office. See below for full title. Method and system for providing a colour match between a scanned colour test pattern and the respective printout of a colour printer, using a closed control loop
Entry Type 25.18 Staff ID. Auth ID. EPT

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STATUS PATENT IN FORCE

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