(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 247 654 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
12.07.2006 Bulletin 2006/28

(51) Int Cl.:
B41J 2/36 *(2006.01)* ***B41J 29/393*** *(2006.01)*

(21) Application number: **01000107.1**

(22) Date of filing: **05.04.2001**

(54) **Method for calibrating a thermal printer**

Verfahren zur Eichung eines Thermodruckers

Procédé pour calibrer une imprimante thermique

(84) Designated Contracting States:
DE FR GB

(43) Date of publication of application:
09.10.2002 Bulletin 2002/41

(73) Proprietor: **AGFA-GEVAERT**
2640 Mortsel (BE)

(72) Inventors:
- **Kaerts, Eric**
  2640, Mortsel (BE)
- **Herrmann-Biber,Bartholomaus**
  Postfach 900151
  81536 München (DE)

(56) References cited:
EP-A- 0 453 714 **US-A- 5 378 563**
US-A- 5 528 270

- **PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) & JP 11 184190 A (OKI DATA CORP), 9 July 1999 (1999-07-09)**
- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 20, 10 July 2001 (2001-07-10) & JP 2001 058423 A (FUJI PHOTO FILM CO LTD), 6 March 2001 (2001-03-06)**
- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 21, 3 August 2001 (2001-08-03) & JP 2001 088328 A (CANON INC), 3 April 2001 (2001-04-03)**

EP 1 247 654 B1

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method for applying thermal energy to a recording medium, using a thermal head having energisable heating elements which are individually addressable. More specifically the invention concerns a method for calibrating a continuous tone thermal printer. In particular, the recording medium is a thermographic material, and the method for thermal printing relates to thermography.

BACKGROUND OF THE INVENTION

[0002] Thermal imaging or thermography is a recording process wherein images are generated by the use of imagewise modulated thermal energy. Thermography is concerned with materials which are not photosensitive, but are sensitive to heat or thermosensitive and wherein imagewise applied heat is sufficient to bring about a visible change in a thermosensitive imaging material, by a chemical or a physical process which changes the optical density.

[0003] Most of the direct thermographic recording materials are of the chemical type. On heating to a certain conversion temperature, an irreversible chemical reaction takes place and a coloured image is produced.

[0004] In direct thermal printing, the heating of the thermographic recording material may be originating from image signals which are converted to electric pulses and then through a driver circuit selectively transferred to a thermal print head. The thermal print head consists of microscopic heat resistor elements, which convert the electrical energy into heat via the Joule effect. The electric pulses thus converted into thermal signals manifest themselves as heat transferred to the surface of the thermographic material, e.g. paper, wherein the chemical reaction resulting in colour development takes place. This principle is described in "Handbook of Imaging Materials" (edited by Arthur S. Diamond - Diamond Research Corporation - Ventura, California, printed by Marcel Dekker, Inc. 270 Madison Avenue, New York, ed. 1991, p. 498-499).

[0005] A particular interesting direct thermal imaging element uses an organic silver salt in combination with a reducing agent. An image can be obtained with such a material because under influence of heat the silver salt is developed to metallic silver.

[0006] A thermal printer varies the printing energy to control the density of the thermal print. The objective is to print predictable densities with minimum increments to produce a nearly continuous grey scale over the desired density range. Typically, control is a two stage process.

[0007] A traditional technique for calibrating a thermal printer is as follows.

First, a first calibration page is printed with a limit setting to produce the desired maximum density and a full range of print settings. The next step is to determine whether this is the desired limit setting by visually inspecting the printed page. The normal objective is to find the minimum exposure required to print the full range of desired densities. The lower the limit setting, the more nearly continuous the grey scale in the printed film. The process of printing and adjusting the maximum limit setting is repeated until a desired limit setting is determined.

[0008] Next, a second calibration page is printed with the limit system setting selected and with a subset of print system settings which cover the full range of print settings. The resulting densities of the printed page are then measured and a print setting to density table created for the full range of print settings. An output lookup table that can be used to set exposure to produce the desired density for any digital image value is created using the print setting to density table. Thereafter the thermal printer prints pages with this output lookup table to produce the desired densities while the same maximum exposure is appropriate.

However, if maximum exposure is changed the calibration process must be repeated.

[0009] In EP 453 714 the amount of energy fed to the printing elements for a certain gradation number can be changed to adapt to variable characteristics of different recording materials. This is based upon test prints to map the input data to the matching signal send to each heating element of the printing head.

[0010] A problem which arises with this calibration technique is that calibration data is specific to a particular limit control setting.

If that setting needs to be changed the entire process of successive prints to find the desired limit control setting for maximum density and calibration must be repeated. Also, if different users want different maximum densities each requires separate calibration. Such repeated calibrations is inefficient, costly and non-productive.

OBJECTS OF THE INVENTION

[0011] It is an object of the present invention to provide an improved calibration method for recording an image on a thermal imaging element by means of a thermal head having energisable heating elements.

It is a further object of the invention that the calibration method has the ability to produce a single calibration page and to derive from that single page sufficient information to produce calibrated prints over a wide range of densities.

[0012] Other objects and advantages of the present invention will become clear from the description and the drawings.

SUMMARY OF THE INVENTION

[0013] The above mentioned objects are realised by a calibration method having the characteristics defined in claim 1. Specific features for preferred embodiments of the invention are set out in the dependent claims.

[0014] Further advantages and embodiments of the present invention will become apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention will be described hereinafter with reference to the accompanying drawings, which are not intended to restrict the scope of the present invention.
Herein,

Figure 1 shows a preferred embodiment of a calibration method according to the present invention, and
Figure 2 is a diagram showing experimentally measured densities and finally obtained densities in relation to printer data.

DETAILED DESCRIPTION OF THE INVENTION

[0016] For sake of good understanding it is mentioned that in this specification often an index "i" is used in relation to certain data (e.g. printer data P_i , a density Di, thermal head data TH_i , rescaled thermal head data Th_i' , etc), whereas an index "j" is used to indicate a user-related variable (e.g. $Prefnew_j$, a desired density $Dwant_j$,...). Of course, in some situations, a combination of both indexes is applicable (e.g. a density D_{ji}). In order to keep the reading of the specification as easy as possible, often such combined index "ji" is simplified to a single index "i", although people skilled in the art may very well understand that implicitly a combined index "ji" is understood.

[0017] First, attention is focused on the drawings, wherein figure 1 shows a preferred embodiment of a calibration method according to the present invention, and wherein figure 2 is a diagram showing experimentally measured densities and finally obtained densities in relation to printer data. As to Fig.1, a so called "slicing" and a so called "duty cycle" (in this drawing indicated with "DC") are explained in full depth e.g. in EPA-01000003.2 (in the name of Agfa-Gevaert); an example of a "user taste" (in this drawing indicated by the abbreviation "U") is explained e.g. in EP-0536822 (in the name of Agfa-Gevaert), a type of a "compensation" (in this drawing indicated with "TPH-Control - compensations") and the meaning of a "voltage supplied to the thermal head" (in this drawing indicated with "V_{TH}") are explained in full depth e.g. in EP-0714780 (in the name of Agfa-Gevaert). For sake of conciseness, no redundant descriptions are repeated for said technical terms.

[0018] In the present specification the term "reference printing power Pref" means the power dissipated under reference conditions comprising V_{TH} , Rref and Dcref, and more particularly the time-averaged power dissipated during a 100% time slice.

[0019] According to the present invention and in reference to figures 1 and 2, a method for calibrating a thermal printer comprising a thermal head incorporating a plurality of energisable heating elements, comprises the steps of:

- supplying to said thermal printer a thermographic material m, a plurality of printer data P_i each intended to be recorded as a pixel having a density D_{ji} , and default reference values for printing parameters Π comprising a value Pref for a reference printing power;
- printing a calibration pattern for said plurality of printer data P_i, said calibration pattern comprising a multiple step density wedge such that a whole range of a relation $D_{ji}(P_i)$ between said printer data P_i and said density D_{ji} is covered;
- measuring a density $Dexp_i$ (see Fig. 2) for each patch of said density wedge of said calibration pattern in relation to said plurality of printer data P_i and storing a first set S1 = (Pref, P_i, $Dexp_i$) in a first memory M1;
- calculating, for a desired density $Dwant_j$ (see Fig. 2 illustrating $Dwant_j$ being 2.50 or being 3.00), a corresponding value $Prefnew_j$ for said reference printing power and storing a second set S2 = ($Dwant_j$, $Prefnew_j$) in a second memory M2;

calculating, for said desired density $Dwant_j$, for each printer data P_i a corresponding density D_{ji} and storing a third set S3 = ($Dwant_j$, $Prefnew_j$, P_i, D_{ji}) in a third memory M3.

[0020] Taking into account the remarks about the indexes "i", "j" and "ji", all further embodiments will be indicated with a single index "i" instead of a combined index "ji".

As a comparative example, the just mentioned embodiment now is also rephrased with single indexes "i".

[0021] Thus, the invention can be rephrased as a method for calibrating a thermal printer comprising a thermal head incorporating a plurality of energisable heating elements, said method comprising the steps of:

- supplying to said thermal printer a thermographic material m , a plurality of printer data P_i each intended to be recorded as a pixel having a density Di , and default reference values for printing parameters Π comprising a value Pref for a reference printing power;
- printing a calibration pattern for said plurality of printer data P_i, said calibration pattern comprising a multiple step density wedge such that a whole range of a relation $Di(P_i)$ between said printer data P_i and said density Di is covered;
- measuring a density $Dexp_i$ for each patch of said density wedge of said calibration pattern in relation to said plurality of printer data P_i and storing a first set S1 = (Pref, P_i, $Dexp_i$) in a first memory M1;
- calculating, for a desired density $Dwant_j$, a corresponding value $Prefnew_j$ for said reference printing power and storing a second set S2 = ($Dwant_j$, $Prefnew_j$) in a second memory M2;
- calculating, for said desired density $Dwant_j$, for each printer data P_i a corresponding density Di and storing a third set S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) in a third memory M3.

[0022] In a preferred embodiment according to the present invention, a method for calibrating a thermal printer comprising a thermal head incorporating a plurality of energisable heating elements, said method comprising the steps of:

- supplying a thermographic material m , a plurality of printer data P_i to be recorded, and default reference values for printing parameters Π comprising a value Pref for a reference printing power;
- printing a calibration pattern for said plurality of printer data P_i , said calibration pattern comprising a multiple step density wedge such that a whole range of a relation $Di(P_i)$ between said printer data P_i and said density Di is covered;
- measuring a density $Dexp_i$ for each patch of said density wedge of said calibration pattern in relation to said plurality of printer data P_i and storing a first set S1 = (Pref, P_i, $Dexp_i$) in a first memory M1;
- transforming said printer data P_i to thermal head data TH_i (see Fig. 1) according to a transformation H applying H $(P_i) \geq TH_0$ and $H(P_m) \geq H(P_n)$ for $P_m > P_n$, wherein TH_0 is a minimal value of thermal head data to be addressed, and wherein P_m and P_n are arbitrary values of said printer data P_i ;
- finding a value $THDwant_j$ for said thermal head data TH_i corresponding with said desired density $Dwant_j$;
- calculating, at said desired density $Dwant_j$, a corresponding value $Prefnew_j$ for said reference printing power taking into account said Pref, said $THDwant_j$ and THmax, wherein THmax is a maximal value of thermal head data that can be addressed, and storing a fourth set S4 = ($Dwant_j$, $Prefnew_j$) in a fourth memory M4;
- calculating, for said desired density $Dwant_j$, for each available printer data P_i a corresponding density Di and storing a sixth set S6 = ($Dwant_j$, $Prefnew_j$, P_j, D_j) into a sixth memory M6.

[0023] It may be indicated that in practice, the contents of memory M2 often equals to the contents of memory M4. The same applies to the contents of memories M3 and M6.

[0024] In a preferred embodiment according to the present invention, a method for calibrating a thermal printer comprising a thermal head incorporating a plurality of energisable heating elements, said method comprises the steps of:

- supplying a thermographic material m , a plurality of printer data P_i to be recorded, and default reference values for printing parameters Π comprising a value Pref for a reference printing power;
- printing a calibration pattern for said plurality of printer data P_i, said calibration pattern comprising a multiple step density wedge such that a whole range of a relation $Di(P_i)$ between said printer data P_i and said density Di is covered;
- measuring a density $Dexp_i$ for each patch of said density wedge of said calibration pattern in relation to said plurality of printer data P_i and storing a first set S1 = (Pref, P_i, $Dexp_i$) in a first memory M1;
- transforming said printer data P_i to thermal head data TH_i according to a transformation H applying $H(P_i) \geq TH_0$ and $H(P_m) \geq H(P_n)$ for $P_m > P_n$, wherein TH_0 is a minimal value of thermal head data to be addressed, and wherein P_m and P_n are arbitrary values of said printer data P_i ;
- finding a value $THDwant_j$ for said thermal head data TH_i corresponding with said desired density $Dwant_j$;
- calculating, at said desired density $Dwant_j$, a corresponding value $Prefnew_j$ for said reference printing power taking into account said Pref, said $THDwant_j$ and THmax, wherein THmax is a maximal value of thermal head data that can be addressed, and storing a fourth set S4 = ($Dwant_j$, $Prefnew_j$) in a fourth memory M4;
- converting said thermal head data TH_i into rescaled thermal head data Th_i' taking into account TH_i, said $THDwant_j$ and said Thmax;
- recalculating said rescaled thermal head data TH_i' into rescaled printer data P_i' according to a transformation H' characterised by $H'(TH') \geq 0$ and $H'(TH'_m) \geq H'(TH'_n)$ for $TH'_m > TH'_n$;

- storing a relation S5 between said rescaled printer data P_i' and said measured density $Dexp_i$ (from S1) into a fifth memory M5;
- deriving from said relation S5 (in memory M5), for said desired density $Dwant_j$, for each available printer data P_i a corresponding density Di and storing a sixth set S6 = ($Dwant_j$, $Prefnew_j$, P_j, D_j) into a sixth memory M6.

[0025] In a possible embodiment, said steps of supplying, printing a calibration pattern, and measuring a density $Dexp_i$ for each patch of said density wedge, are replaced by capturing a new value for a desired density $Dwant_j$.

[0026] In further preferred embodiment according to the present invention, said step of printing a calibration pattern is preceded by the steps

- supplying to said thermal printer a plurality of image data d to be recorded on said thermographic material m;
- first converting said image data d into density data Di according to a desired relation U between each of said image data d and a corresponding density Di;
- second converting said density data Di into printer data P_i by using the (P, D_i) information in a previous set S3prev corresponding to said $Dwant_j$;
- storing thus (twice) converted image data d as a set S7 = (d,P_i) into a seventh memory M7.

[0027] In a further preferred embodiment according to the present invention, said steps of first converting said image data d and of second converting said density data Di are carried out by a transforming according to T = S^{-1} o U (meaning that operation first U has to be carried out, and thereafter operation S^{-1} ; see also Fig. 1)

[0028] In a still further preferred embodiment according to the present invention, said default reference values for printing parameters Π are selected from the group of a reference value for a resistance value Reref of a heating element (e.g. Reref = 3000 Ω), a reference value DCref for a duty cycle (e.g. Dcref = 70%), and a reference value Tref for a base-temperature of a heating element (e.g. Tref = 25 °C) .

[0029] In a still further preferred embodiment, said calculating, a corresponding value $Prefnew_j$ is carried out according to

$$\mathrm{Prefnew}_j = \mathrm{Pref}.\frac{TH_{Dwant_j}}{TH_{\max}} .$$

[0030] In a still further preferred embodiment according to the present invention, said converting said thermal head data TH_i into rescaled thermal head data TH_i' is carried out according to

$$\mathrm{TH}_i' = \mathrm{TH}_i.\frac{TH_{\max}}{TH_{Dwant_j}} .$$

[0031] In a still further preferred embodiment according to the present invention, said transforming said printer data P_i to thermal head data TH_i is carried out according to

$$\mathrm{TH}_i = \mathrm{TH}_0 + \mathrm{P}_i.\frac{(2^N-1-TH_0)}{2^N-1}$$

wherein N is a bitdepth (representing a number of bits pro value) of said thermal head data TH_i.

[0032] In a still further preferred embodiment according to the present invention, said recalculating said rescaled thermal head data TH_i' into rescaled printer data P_i' is carried out according to

$$\mathrm{P}_i' = (\mathrm{TH}_i' - \mathrm{TH}_0).\frac{2^N-1}{2^N-1-TH_0} .$$

[0033] In a another preferred embodiment according to the present invention, a method further comprises the step of searching two consecutive values of thermal head data TH_k and TH_l which correspond with densities D_k and D_l wherein between a desired density $Dwant_j$ is enclosed.

[0034] In a another preferred embodiment, said step of transforming said printer data P_i to thermal head data TH_i applies according to following equation:

$$TH_i = TH_0 + P_i . \frac{(2^N - 1 - TH_0)}{2^M - 1}$$

wherein N is a bitdepth (representing a number of bits)of said thermal head data TH, and M is a bitdepth (representing a number of bits) of said printer data P_i, and wherein M is different from N, preferably N > M.
In a highly preferred embodiment, e.g. M= 10 or 12, and N = 13.

[0035] In a another preferred embodiment, a method for thermal recording by means of a thermal head incorporating a plurality of energisable heating elements H_n and using a calibration method according to anyone of the preceding disclosures.

[0036] In still another preferred embodiment, said thermographic material comprises on a support a thermosensitive layer incorporating an organic silver salt and a reducing agent contained in said thermosensitive layer and/or in another optional layer.

[0037] An apparatus for thermal recording an image on a thermographic material can use a method as described hereabove.

[0038] In a possible embodiment, said output values Dh_k, Dh_{kcm} and Dh_{kcml} relate to values of an optical density and/or to values of a pixel size to be reproduced on said thermographic material m.

[0039] An experiment to test the performance of a calibration method according to the present invention was carried out on a Drystar3000 thermal printer (commercially available from Agfa-Gevaert). The results of the most important steps of the calibration procedure are listed in table (in appendix; page 15).

[0040] A 27 step calibration wedge was printed at a reference printing power Pref of 75.6 mW. The 27 printer data values P1, P2, ... P27 lay between 411 and 1023. The 27 corresponding experimental density values lay between 0.23 and 3.49.

[0041] The 27 printer data values P1, P2, ..., P27 were transformed to 27 thermal head data values TH1, TH2, ... , TH27.

[0042] In the described example, the above listed experimental results from the single calibration page were further used to obtain all the necessary information to guarantee high quality printouts at two different values of Dwant, e.g. Dwant = 2.50 and Dwant = 3.00.

[0043] THDwant and Prefnew were calculated. For Dwant = 2.50, THDwant = 6950 and consequently Prefnew = 64.1 mW. For Dwant = 3.00 on the other hand, THDwant = 7436 and Prefnew = 68.1 6W.

[0044] For each Dwant-value, the rescaled P-values (indicated by the symbol P') were calculated and the output lookup table that is used during printing to set the appropriate energy to produce the desired density for any digital image value was created.

[0045] Finally, the quality of the calibration was tested by printing at said two values of Dwant, i.c. 2.50 and 3.00, another test wedge, in particular a 33 step test wedge, and by comparing the experimental densities with the desired densities. Over the full density range, the difference between two corresponding densities was never larger than 2%. This result clearly demonstrates that the objects of the present invention are realised.

[0046] Thermal imaging according to the present invention can be used for production of both transparencies and reflection-type prints. In the hard copy field, thermographic recording materials based on an opaque (e.g. white) base are used, whereas in the medical diagnostic field monochrome (e.g. black) images on a transparent base find wide application, since such prints can conveniently be viewed by means of a light box.

[0047] The method of the present invention is applicable for a wide variety of printing techniques.

[0048] In "Direct thermal printing", the method may be directed towards representing an image of a human body obtained during medical imaging and to a printing of medical image picture data received from a medical imaging device, e.g. a medical image camera.

[0049] Another application of the present invention comprises
hardcopy printing for so-called non-destructive Testing (NDT), based on e.g. radiographic or on ultrasonic systems. Exemplary purposes of NDT comprise inspection or quality control of materials, welded joints or assemblies; development of manufacturing processes; experimenting in research; etc.

[0050] In another preferred embodiment of the present invention, the image data may be graphical image picture data received e.g. from a computerised publishing system. Further, a method according to the present invention also may be applied in graphic plotters, in chart recorders, in computer printers, etc.

[0051] In a still further preferred embodiment, said densities (as e.g. D_{ji}, $Dexp_i$ and $Dwant_j$) relate to values of an optical density and/or to values of a pixel size to be reproduced on said thermographic material m.

[0052] Further, it is important to indicate that for people skilled in the art, a so-called heating element may comprise e.g. a resistive heating element, an inductive heating element, a pyrotechnic heating element, or a high frequency heating element.

[0053] Having described preferred embodiments of the current invention, it will now be apparent to those skilled in the art that numerous modifications can be made therein without departing from the scope of the invention as defined in the appending claims.

Experiment	Dwant = 3.00	Dwant = 2.50
	THDwant = 7436	THDwant = 6950
Pref = 75.6 mW	Prefnew = 68.6 mW	Prefnew = 64.1 mW

Patch	P_i	$Dexp_i$	TH_i	TH'_i	P'_i	$Dexp_i$	TH'_i	P'_i	$Dexp_i$
1	411	0.23	3636	4005	460	0.23	4285	498	0.23
2	435	0.23	3815	4202	487	0.23	4496	526	0.23
3	458	0.23	3986	4391	512	0.23	4698	553	0.23
4	482	0.23	4164	4587	538	0.23	4908	581	0.23
5	505	0.24	4336	4776	564	0.24	5110	609	0.24
6	529	0.26	4514	4973	590	0.26	5320	637	0.26
7	552	0.28	4685	5161	615	0.28	5522	664	0.28
8	576	0.33	4864	5358	642	0.33	5733	692	0.33
9	599	0.37	5035	5546	667	0.37	5934	719	0.37
10	623	0.48	5214	5743	694	0.48	6145	748	0.48
11	646	0.57	5385	5932	719	0.57	6347	775	0.57
12	670	0.75	5564	6129	745	0.75	6557	803	0.75
13	693	0.89	5735	6317	771	0.89	6759	830	0.89
14	717	1.15	5913	6514	797	1.15	6969	858	1.15
15	740	1.33	6085	6702	823	1.33	7171	885	1.33
16	764	1.61	6263	6899	849	1.61	7382	914	1.61
17	787	1.81	6434	7088	874	1.81	7583	941	1.81
18	811	2.08	6613	7285	901	2.08	7794	969	2.08
19	834	2.27	6784	7473	926	2.27	7996	996	2.27
20	858	2.52	6963	7670	952	2.52	8191	1023	2.50
21	881	2.70	7134	7858	978	2.70			
22	905	2.89	7313	8055	1004	2.89			
23	928	3.04	7484	8191	1023	3.00			
24	952	3.19	7663						
25	975	3.31	7834						
26	999	3.40	8012						
27	1023	3.49	8191						

Table 1

Claims

1. A method for calibrating a thermal printer comprising a thermal head incorporating a plurality of energisable heating elements, said method comprising the steps of:

- supplying to said thermal printer a thermographic material m , a plurality of printer data P_i each intended to be recorded as a pixel having a density Di , and default reference values for printing parameters Π comprising a value Pref for a reference printing power;
- printing a calibration pattern for said plurality of printer data P_i, said calibration pattern comprising a multiple step density wedge such that a whole range of a relation $Di(P_i)$ between said printer data P_i and said density Di is covered;
- measuring a density $Dexp_i$ for each patch of said density wedge of said calibration pattern in relation to said plurality of printer data P_i and storing a first set S1 = (Pref, P_i, $Dexp_i$) in a first memory M1;
- calculating, for a desired density $Dwant_j$, a corresponding value $Prefnew_j$ for said reference printing power and storing a second set S2 = ($Dwant_j$, $Prefnew_j$) in a second memory M2;
- calculating, for said desired density $Dwant_j$, for each printer data P_i a corresponding density Di and storing a third set S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) in a third memory M3.

2. A method according to claim 1 further including directly after the measuring step the steps of:

- transforming said printer data P_i to thermal head data TH_i according to a transformation H applying $H(P_i) \geq TH_0$ and $H(P_m) \geq H(P_n)$ for $P_m > P_n$, wherein TH_0 is a minimal value of thermal head data to be addressed, and wherein P_m and P_n are arbitrary values of said printer data P_i ;
- finding a value $THDwant_j$ for said thermal head data TH_i corresponding with said desired density $Dwant_j$;

and wherein the following step of calculating, for a desired density $Dwant_j$, a corresponding value $Prefnew_j$ for said reference printing power and storing a second set S2 = ($Dwant_j$, $Prefnew_j$) in a second memory M2, takes into account said Pref, said $THDwant_j$ and THmax, wherein THmax is a maximal value of thermal head data that can be addressed.

3. A method according to claim 2 wherein the final step according to claim 1 of calculating, for said desired density $Dwant_j$, for each printer data P_i a corresponding density Di and storing a third set S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) in a third memory M3, comprises the steps of :

- converting said thermal head data TH_i into rescaled thermal head data Th_i' taking into account TH_i, said $THDwant_j$ and said Thmax;
- recalculating said rescaled thermal head data TH_i' into rescaled printer data P_i' according to a transformation H' **characterised by** $H'(TH') \geq 0$ and $H'(TH'_m) \geq H'(TH'_n)$ for $TH'_m > TH'_n$;
- storing a relation S5 between said rescaled printer data P_i' and said measured density $Dexp_i$ (from S1) into a fifth memory M5;
- deriving from said relation S5 (in memory M5), for said desired density $Dwant_j$, for each available printer data P_i a corresponding density Di and storing a sixth set S6 = ($Dwant_j$, $Prefnew_j$, P_j, D_j) into a sixth memory M6.

4. A method according to anyone of the claims 1-3, wherein said step of printing a calibration pattern is preceded by the steps of

- supplying to said thermal printer a plurality of image data d to be recorded on said thermographic material m;
- first converting said image data d into density data Di according to a desired relation U between each of said image data d and a corresponding density Di;
- second converting said density data Di into printer data P_i by using the (P, D_i) information in a previous set S3prev corresponding to said $Dwant_j$;
- storing thus (twice) converted image data d as a set S7 = (d,Pi) into a seventh memory M7.

5. A method according to claim 4, wherein said steps of first converting said image data d and of second converting said density data Di are carried out by a transforming according to $T = S^{-1} \circ U$.

6. A method according to anyone of the claims 1-3 wherein said default reference values for printing parameters Π are selected from the group of a reference value for a resistance value Reref of a heating element, a reference value

DCref for a duty cycle, and a reference value Tref for a base temperature of a heating element.

7. A method according to claim 2 or 3, wherein said calculating, a corresponding value $Prefnew_j$ is carried out according to

$$Prefnew_j = Pref.\frac{TH_{Dwant_j}}{TH_{max}}.$$

8. A method according to claim 2 or 3, wherein said converting said thermal head data TH_i into rescaled thermal head data TH_i' is carried out according to

$$TH_i' = TH_i.\frac{TH_{max}}{TH_{Dwant_j}}.$$

9. A method according to claim 2 or 3, wherein said transforming said printer data P_i to thermal head data TH_i is carried out according to

$$TH_i = TH_0 + P_i.\frac{(2^N-1-TH_0)}{2^N-1}$$

wherein N is a bitdepth (representing a number of bits pro value) of said thermal head data TH_i.

10. A method according to claim 2 or 3, wherein said recalculating said rescaled thermal head data TH_i' into rescaled printer data P_i' is carried out according to

$$P_i' = (TH_i' - TH_0).\ \frac{2^N-1}{2^N-1-TH_0}.$$

11. A method according to claim 2 or 3, further comprising the step of searching two consecutive values of thermal head data TH_k and TH_l which correspond with densities D_k and D_l wherein between a desired density $Dwant_j$ is enclosed.

12. A method according to claim 2, wherein said step of transforming said printer data P_i to thermal head data TH_i applies according to following equation:

$$TH_i = TH_0 + P_i.\frac{(2^N-1-TH_0)}{2^M-1}$$

wherein N is a bitdepth (representing a number of bits)of said thermal head data TH, and M is a bitdepth (representing a number of bits) of said printer data P_i, and wherein M is different from N.

13. A method for thermal recording by means of a thermal head incorporating a plurality of energisable heating elements H_n and using a calibration method according to anyone of the preceding claims.

14. A method according to anyone of the preceding claims, wherein said thermographic material comprises on a support a thermosensitive layer incorporating an organic silver salt and a reducing agent contained in said thermosensitive layer and/or in another optional layer.

Patentansprüche

1. Verfahren zum Kalibrieren eines Thermodruckers umfassend einen Thermokopf mit mehreren bestrombaren Heizelementen, mit den folgenden Schritten:

- Beliefern des Thermodruckers mit einem thermographischen Material m, mehreren Druckerdaten P_i, die jeweils als ein Pixel mit einer Dichte Di aufgezeichnet werden sollen, und Standardreferenzwerte zum Drucken von Parametern Π umfassend einen Wert Pref für eine Referenzdruckleistung;
- Drucken eines Kalibrierungsmusters für die mehreren Druckerdaten P_i, wobei das Kalibrierungsmuster einen mehrstufigen Dichtekeil derart umfasst, dass ein ganzer Bereich einer Beziehung Di (P_i) zwischen den Druckerdaten P_i und der Dichte Di abgedeckt ist;
- Messen einer Dichte $Dexp_i$ für jedes Feld des Dichtekeils des Kalibrierungsmusters in Relation zu den mehreren Druckerdaten P_i und Speichern einer ersten Menge S1 = (Pref, P_i, $Dexp_i$) in einem ersten Speicher M1;
- Berechnen für eine gegebene Dichte $Dwant_j$ eines entsprechenden Werts $Prefnew_j$ für die Referenzdruckleistung und Speichern einer zweiten Menge S2 .= ($Dwant_j$, $Prefnew_j$) in einem zweiten Speicher M2;
- Berechnen für die gewünschte Dichte $Dwant_j$ für alle Druckerdaten P_i einer entsprechenden Dichte Di und Speichern einer dritten Menge S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) in einem dritten Speicher M3.

2. Verfahren nach Anspruch 1, weiterhin direkt nach dem Messschritt mit den weiteren Schritten:

- Transformieren der Druckerdaten P_i in Thermokopfdaten TH_i gemäß einer Transformation H, die $H(P_{i)} \geq TH_0$ und $H(P_m) \geq H(P_n)$ für $P_m > P_n$ anwendet, wobei TH_0 ein Mindestwert von zu adressierenden Thermokopfdaten ist und wobei P_m und P_n willkürliche Werte der Druckerdaten P_i sind;
- Finden eines Werts $THDwant_j$ für die Thermokopfdaten TH_i entsprechend der gewünschten Dichte $Dwant_j$;

und wobei der folgende Schritt des Berechnens für eine gewünschte Dichte $Dwant_j$ eines entsprechenden Werts $Prefnew_j$ für die Referenzdruckleistung und Speichern einer zweiten Menge S2 = ($Dwant_j$, $Prefnew_j$) in einem zweiten Speicher M2 Pref, $THDwant_j$ und THmax berücksichtigt, wobei THmax ein Höchstwert von Thermokopfdaten ist, die adressiert werden können.

3. Verfahren nach Anspruch 2, wobei der Endschritt gemäß Anspruch 1 des Berechnens für die gewünschte Dichte $Dwant_j$ für alle Druckerdaten P_i einer entsprechenden Dichte Di und Speichern einer dritten Menge S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) in einem dritten Speicher M3 die folgenden Schritte umfasst:

- Umwandeln der Thermokopfdaten TH_i in umskalierte Thermokopfdaten TH_i' unter Berücksichtigung von TH_i, $THDwant_j$ und THmax;
- Neuberechnen der umskalierten Thermokopfdaten TH_i' in umskalierte Druckerdaten P_i' gemäß einer Transformation H' **gekennzeichnet durch** $H'(TH') \geq 0$ und $H'(TH'_m) \geq H'(TH'_n)$ für $TH'_m \geq TH'_n$;
- Speichern einer Relation S5 zwischen den umskalierten Druckerdaten P_i' und der gemessenen Dichte $Dexp_i$ (von S1) in einen fünften Speicher M5;
- Ableiten der Relation S5 (im Speicher M5) für die gewünschte Dichte $Dwant_j$ für alle verfügbaren Druckerdaten P_i einer entsprechenden Dichte Di und Speichern einer sechsten Menge S6 = $Dwant_j$, $Prefnew_j$, P_j, D_j) in einem sechsten Speicher M6.

4. Verfahren nach einem der Ansprüche 1-3, wobei dem Schritt des Druckens eines Kalibrierungsmusters die folgenden Schritte vorausgehen:

- Beliefern des Thermodruckers mit mehreren Bilddaten d zur Aufzeichnung auf dem thermographischen Material m;
- erstes Umwandeln der Bilddaten d in Dichtedaten Di gemäß einer gewünschten Beziehung U zwischen jeder der Bilddaten d und einer entsprechenden Dichte Di;
- zweites Umwandeln der Dichtedaten Di in Druckerdaten P_i unter Verwendung der (P, Di) Informationen in einer vorausgegangenen Menge S3prev entsprechend $Dwant_j$;
- Speichern der (zwei Mal) umgewandelten Bilddaten d als eine Menge S7 = (d, P_i) in einem siebten Speicher M7.

5. Verfahren nach Anspruch 4, wobei die Schritte des ersten Umwandelns der Bilddaten d und des zweiten Umwandelns der Dichtedaten Di durch ein Transformieren gemäß $T = S^{-1} \circ U$ ausgeführt werden.

6. Verfahren nach einem der Ansprüche 1 bis 3, wobei die Standardreferenzwerte für Druckparameter Π ausgewählt werden aus der Gruppe aus einem Referenzwert für einen Widerstandswert Reref eines Heizelements, einem Referenzwert DCref für einen Tastzyklus und einem Referenzwert Tref für eine Basistemperatur eines Heizelements.

7. Verfahren nach Anspruch 2 oder 3, wobei das Berechnen eines entsprechenden Werts $Prefnew_j$ ausgeführt wird gemäß

$$\mathrm{Prefnew}_j = \mathrm{Pref} \cdot \frac{TH_{Dwant_j}}{TH_{\max}}$$

8. Verfahren nach Anspruch 2 oder 3, wobei das Umwandeln der Thermokopfdaten TH_i in umskalierte Thermokopfdaten TH_i' ausgeführt wird gemäß

$$TH_i' = TH_i \cdot \frac{TH_{\max}}{TH_{Dwant_j}}$$

9. Verfahren nach Anspruch 2 oder 3, wobei das Transformieren der Druckerdaten P_i in Thermokopfdaten TH_i ausgeführt wird gemäß

$$TH_i = TH_0 + P_i \cdot \frac{(2^N - 1 - TH_0)}{2^N - 1}$$

wobei N eine (eine Anzahl von Bits pro Wert darstellende) Bittiefe der Thermokopfdaten TH_i ist.

10. Verfahren nach Anspruch 2 oder 3, wobei das Neuberechnen der umskalierten Thermokopfdaten TH_i' in umskalierte Druckerdaten P_i' ausgeführt wird gemäß

$$P_i' = (TH_i' - TH_0) \cdot \frac{2^N - 1}{2^N - 1 - TH_0}$$

11. Verfahren nach Anspruch 2 oder 3, weiterhin umfassend den Schritt des Suchens zweier aufeinander folgender Werte von Thermokopfdaten TH_k und TH_l, die den Dichten D_k und D_l entsprechen, wobei dazwischen eine gewünschte Dichte $Dwant_j$ eingeschlossen ist.

12. Verfahren nach Anspruch 2, wobei der Schritt des Transformierens der Druckerdaten P_i in Thermokopfdaten TH_i gemäß der folgenden Gleichung gilt:

$$TH_i = TH_0 + P_i \cdot \frac{(2^N - 1 - TH_0)}{2^M - 1}$$

wobei N eine (eine Zahl von Bits darstellende) Bittiefe der Thermokopfdaten TH und M eine (eine Zahl von Bits darstellende) Bittiefe der Druckerdaten P_i ist und wobei M von N verschieden ist.

13. Verfahren zum thermischen Aufzeichnen mit Hilfe eines Thermokopfs enthaltend mehrere bestrombare Heizelemente H_n und unter Verwendung eines Kalibrierungsverfahrens gemäß einem beliebigen der vorausgegangenen Ansprüche.

14. Verfahren nach einem beliebigen der vorhergehenden Ansprüche, wobei das thermographische Material auf einem Träger eine wärmeempfindliche Schicht umfasst, die ein organisches Silbersalz und ein Reduziermittel enthält, enthalten in der wärmeempfindlichen Schicht und/oder in einer weiteren fakultativen Schicht.

Revendications

1. Procédé de calibrage d'une imprimante thermique comprenant une tête thermique incorporant une pluralité d'éléments chauffants activables, ledit procédé comprenant les étapes consistant à :

- fournir à ladite imprimante thermique une matière thermographique m, une pluralité de données d'imprimante P_i destinées chacune à être enregistrées sous la forme d'un pixel présentant une densité Di, et des valeurs de référence par défaut pour des paramètres d'impression II comprenant une valeur Pref pour une puissance d'impression de référence ;
- imprimer un motif de calibrage pour ladite pluralité de données d'imprimante P_i, ledit motif de calibrage comprenant une barre de contrôle de densité à plusieurs échelons de façon à couvrir toute la plage d'une relation Di(P_i) entre lesdites données d'imprimante P_i et ladite densité Di ;
- mesurer une densité $Dexp_i$ pour chaque secteur de ladite barre de contrôle de densité dudit motif de calibrage relativement à ladite pluralité de données d'imprimante P_i et stocker un premier ensemble Sl = (Pref, P_i, $Dexp_i$) dans une première mémoire M1 ;
- calculer, pour une densité souhaitée $Dwant_j$, une valeur $Prefnew_j$ correspondante pour ladite puissance d'impression de référence et stocker un deuxième ensemble S2 = ($Dwant_j$, $Prefnew_j$) dans une deuxième mémoire M2 ;
- calculer, pour ladite densité souhaitée $Dwant_j$, pour chaque donnée d'imprimante P_i, une densité Di correspondante et stocker un troisième ensemble S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) dans une troisième mémoire M3.

2. Procédé selon la revendication 1, comportant en outre, directement après l'étape consistant à mesurer, les étapes consistant à :

- transformer lesdites données d'imprimante P_i en données de tête thermique TH_i conformément à une transformation H appliquant $H(P_i) \geq TH_0$ et $H(P_m) \geq H(P_n)$ pour $P_m > P_n$, où TH_0 est une valeur minimale de données de tête thermique à adresser, et où P_m et P_n sont des valeurs arbitraires desdites données d'imprimante Pi ;
- déterminer une valeur $THDwant_j$ pour lesdites données de tête thermique TH_i correspondant à ladite densité souhaitée $Dwant_j$;

l'étape suivante consistant à calculer, pour une densité souhaitée $Dwant_j$, une valeur $Prefnew_j$ correspondante pour ladite puissance d'impression de référence et à stocker un deuxième ensemble S2 = ($Dwant_j$, $Prefnew_j$) dans une deuxième mémoire M2 tenant compte de ladite valeur Pref, de ladite valeur $THDwant_j$ et de THmax, où THmax est une valeur maximale de données de tête thermique pouvant être adressées.

3. Procédé selon la revendication 2, l'étape finale selon la revendication 1 consistant à calculer, pour ladite densité souhaitée $Dwant_j$, pour chaque donnée d'imprimante P_i, une densité Di correspondante et stocker un troisième ensemble S3 = ($Dwant_j$, $Prefnew_j$, P_i, Di) dans une troisième mémoire M3, comprenant les étapes consistant à :

- convertir lesdites données de tête thermique TH_i en données de tête thermique remises à l'échelle TH_i' en tenant compte de TH_i, de ladite valeur $THDwant_j$ et de ladite valeur THmax ;
- recalculer lesdites données de tête thermique remises à l'échelle TH_i' pour obtenir des données d'imprimante remises à l'échelle P_i' conformément à une transformation H' **caractérisée par** H'(TH') ≥ 0 et $H'(TH'_m) \geq H'(TH'_n)$ pour $TH'_m > TH'_n$;
- stocker une relation S5 entre lesdites données d'imprimante remises à l'échelle P_i' et ladite densité mesurée $Dexp_i$ (issue de S1) dans une cinquième mémoire M5 ;
- déduire de ladite relation S5 (dans la mémoire M5), pour ladite densité souhaitée $Dwant_j$, pour chaque donnée d'imprimante P_i disponible, une densité Di correspondante et stocker un sixième ensemble S6 = ($Dwant_j$, $Prefnew_j$, P_j, D_j) dans une sixième mémoire M6.

4. Procédé selon l'une quelconque des revendications 1 à 3, ladite étape d'impression d'un motif de calibrage étant précédée des étapes consistant à :

- fournir à ladite imprimante thermique une pluralité de données d'image d à enregistrer sur ladite matière thermographique m ;
- effectuer une première conversion desdites données d'image d en données de densité Di conformément à une relation souhaitée U entre chacune desdites données d'image d et une densité Di correspondante ;
- effectuer une deuxième conversion desdites données de densité Di en données d'imprimante P_i à l'aide des informations (P, Di) dans un ensemble précédent S3prev correspondant à ladite valeur $Dwant_j$;
- stocker les données d'image d ainsi converties (deux fois) sous la forme d'un ensemble S7 = (d, P_i) dans une septième mémoire M7.

5. Procédé selon la revendication 4, lesdites étapes consistant à effectuer une première conversion desdites données d'image d et à effectuer une deuxième conversion desdites données de densité Di étant réalisées par une transformation selon $T = S^{-1} \circ U$.

6. Procédé selon l'une quelconque des revendications 1 à 3, lesdites valeurs de référence par défaut pour les paramètres d'impression Π étant choisies dans le groupe constitué d'une valeur de référence pour une valeur de résistance Reref d'un élément chauffant, d'une valeur de référence DCref pour un rapport cyclique et d'une valeur de référence Tref pour une température de base d'un élément chauffant.

7. Procédé selon la revendication 2 ou 3, ladite étape consistant à calculer une valeur $Prefnew_j$ correspondante étant réalisée conformément à :

$$\mathrm{Prefnew}_j = \mathrm{Pref} \cdot \frac{THDwant_j}{TH\max} .$$

8. Procédé selon la revendication 2 ou 3, ladite étape consistant à convertir lesdites données de tête thermique TH_i en données de tête thermique remises à l'échelle TH_i' étant réalisée conformément à :

$$\mathrm{TH}_i' = \mathrm{TH}_i \cdot \frac{TH\max}{THDwant_j} .$$

9. Procédé selon la revendication 2 ou 3, ladite étape consistant à transformer lesdites données d'imprimante P_i en données de tête thermique TH_i étant réalisée conformément à :

$$\mathrm{TH}_i = \mathrm{TH}_0 + \mathrm{P}_i \cdot \frac{(2^N - 1 - TH_0)}{2^N - 1}$$

où N est une profondeur de bit (représentant le nombre de bits par valeur) desdites données de tête thermique TH_i.

10. Procédé selon la revendication 2 ou 3, ladite étape consistant à recalculer lesdites données de tête thermique remises à l'échelle TH_i' pour obtenir des données d'imprimante remises à l'échelle P_i' étant réalisée conformément à :

$$\mathrm{P}_i' = (\mathrm{TH}_i' - \mathrm{TH}_0) \cdot \frac{2^N - 1}{2^N - 1 - TH_0} .$$

11. Procédé selon la revendication 2 ou 3, comprenant en outre l'étape consistant à rechercher deux valeurs consécutives de données de tête thermique, TH_k et TH_l, correspondant à des densités D_k et D_l qui bornent une densité souhaitée $Dwant_j$.

12. Procédé selon la revendication 2, ladite étape consistant à transformer lesdites données d'imprimante P_i en données de tête thermique TH_i s'appliquant conformément à l'équation suivante :

$$TH_i = TH_0 + P_i . \frac{(2^N - 1 - TH_0)}{2^M - 1}$$

où N est une profondeur de bit (représentant un nombre de bits) desdites données de tête thermique TH, et M est une profondeur de bit (représentant un nombre de bits) desdites données d'imprimante P_i, et où M est différent de N.

13. Procédé d'enregistrement thermique au moyen d'une tête thermique incorporant une pluralité d'éléments chauffants activables H_n et utilisant un procédé de calibrage selon l'une quelconque des revendications précédentes.

14. Procédé selon l'une quelconque des revendications précédentes, ladite matière thermographique comprenant, sur un support, une couche thermosensible incorporant un sel d'argent organique et un agent réducteur contenu dans ladite couche thermosensible et/ou dans une autre couche facultative.

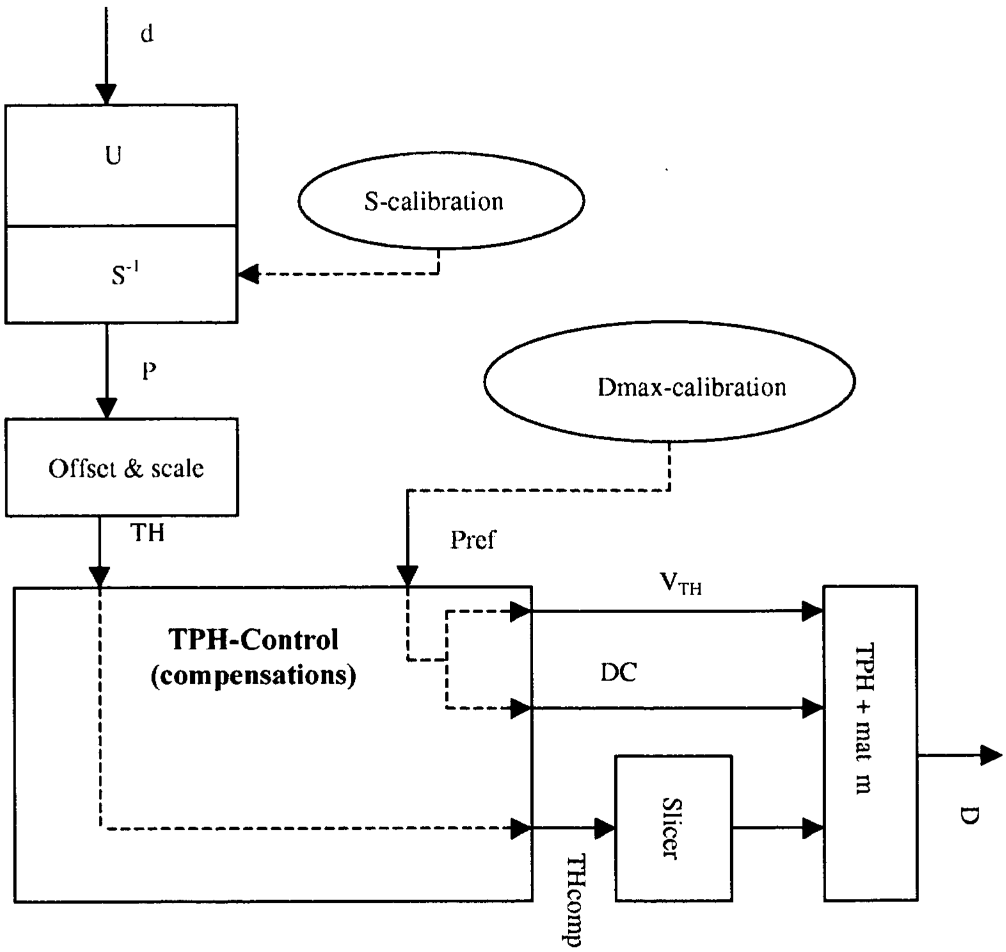
d
U
S-calibration
S^{-1}
P
Dmax-calibration
Offset & scale
TH
Pref
V_{TH}
TPH-Control
(compensations)
DC
TPH + mat m
Slicer
D
THcomp

Fig 1

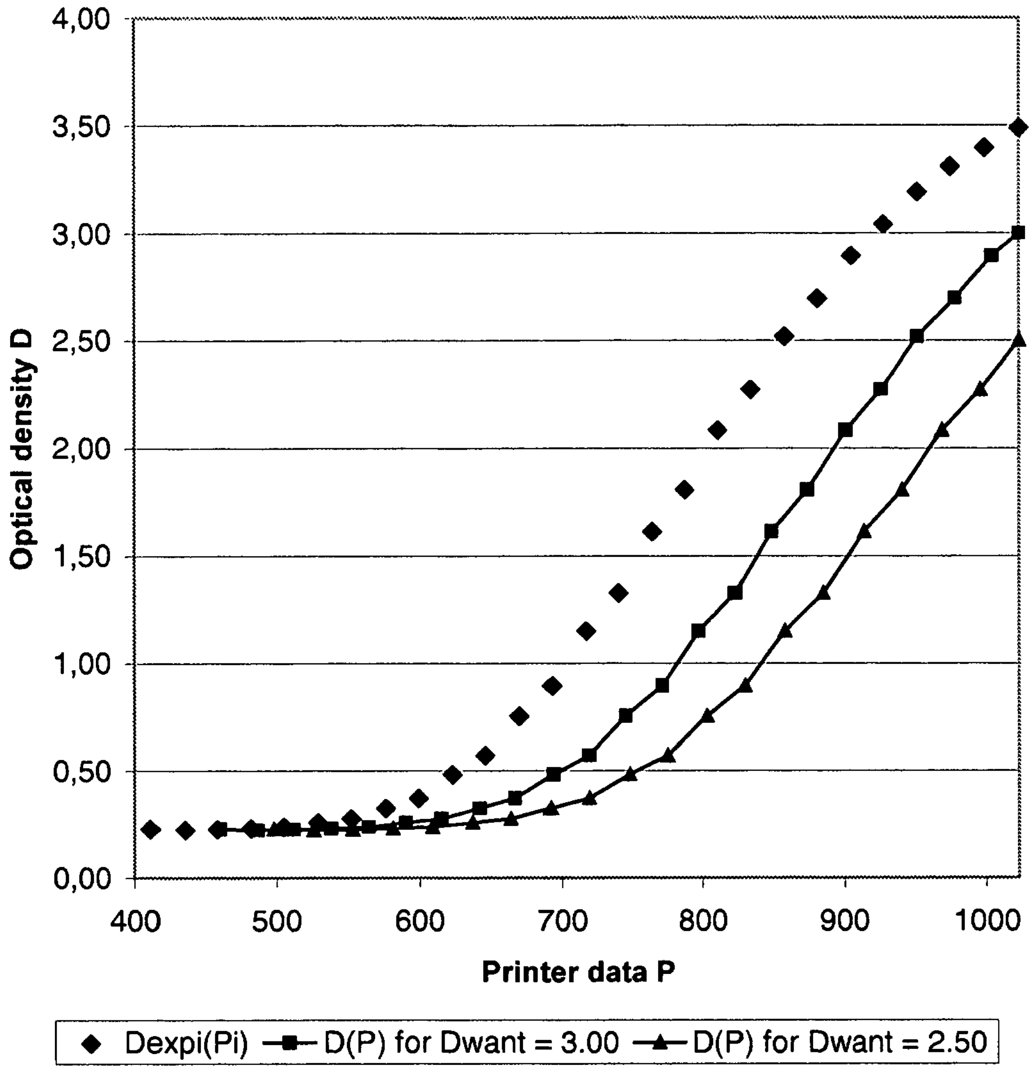
4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
Optical density D
400
500
600
700
800
900
1000
Printer data P
Dexpi(Pi)
D(P) for Dwant = 3.00
D(P) for Dwant = 2.50

FIG. 2