



US005428383A

United States Patent [19]

[11] Patent Number: **5,428,383**

Shields et al.

[45] Date of Patent: * **Jun. 27, 1995**

[54] **METHOD AND APPARATUS FOR PREVENTING COLOR BLEED IN A MULTI-INK PRINTING SYSTEM**

OTHER PUBLICATIONS

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Hewlett-Packard Journal, vol. 39, No. 4 (Aug. 1988): pp. 1-89.

[73] Assignee: **Hewlett-Packard Corporation**, Palo Alto, Calif.

Color Index, vol 4, 3rd Ed., The Society of Dyers and Colourists, Yorkshire, England (1971), pp. 4018, 4035, 4059, 4132, 4193, 4194, 4340, 4385, 4406-4410, 4419, 4618, and 4661.

[*] Notice: The portion of the term of this patent subsequent to Mar. 30, 2010 has been disclaimed.

Primary Examiner—Benjamin R. Fuller
Assistant Examiner—Valerie Ann Lund

[21] Appl. No.: **926,259**

[57] ABSTRACT

[22] Filed: **Aug. 5, 1992**

A method for controlling color bleed in multi-color thermal inkjet printing systems. Color bleed involves the migration of coloring agents between adjacent zones in a multi-color printed image on a substrate. To control color bleed between any two ink compositions in a multi-ink system, at least one of the ink compositions will contain a precipitating agent (e.g. a multivalent metal salt). The precipitating agent is designed to react with the coloring agent in the other ink composition of concern. As a result, when the two ink compositions come in contact, a precipitate is formed from the coloring agent in the other ink composition which prevents migration thereof and color bleed problems. This technique is applicable to printing systems containing two or more ink compositions, and enables distinct multi-color images to be produced without the problems normally caused by color bleed.

[51] Int. Cl.⁶ **C09D 11/02**

[52] U.S. Cl. **347/96**; 106/20 D; 106/20 R

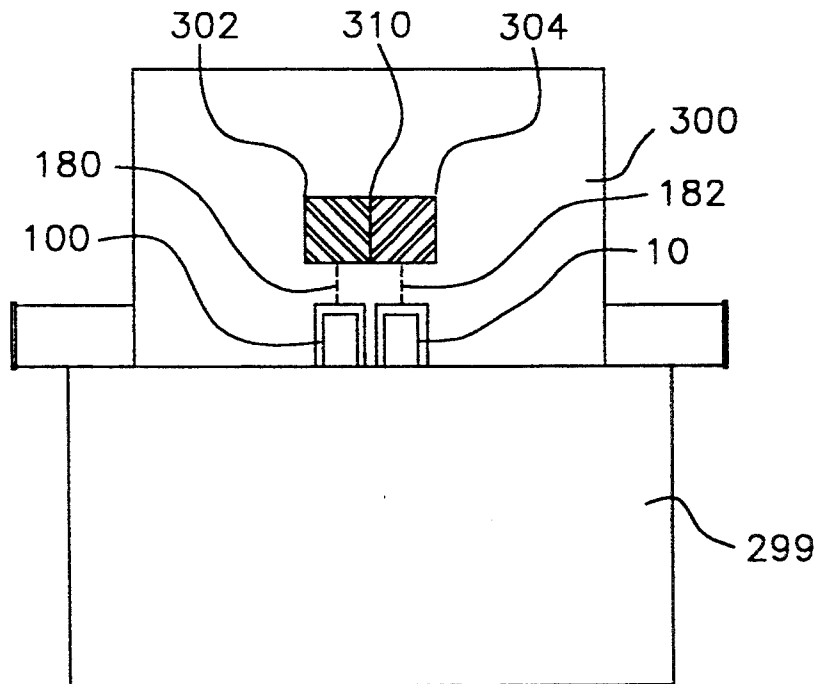
[58] Field of Search 106/20 R, 20 D; 347/96

[56] References Cited

U.S. PATENT DOCUMENTS

4,500,895	2/1985	Buck et al.	347/9
4,740,420	4/1988	Akutsu et al.	428/341
4,771,295	9/1988	Baker et al.	347/9
4,794,409	12/1988	Cowger et al.	222/187
4,818,285	4/1989	Causley et al.	106/20 D
4,963,189	10/1990	Hindagolla	106/22
5,025,271	6/1991	Baker et al.	347/9
5,108,504	4/1992	Johnson et al.	106/25
5,196,056	3/1993	Prasad	106/20 D
5,198,023	3/1993	Stoffel	160/22 R

14 Claims, 3 Drawing Sheets



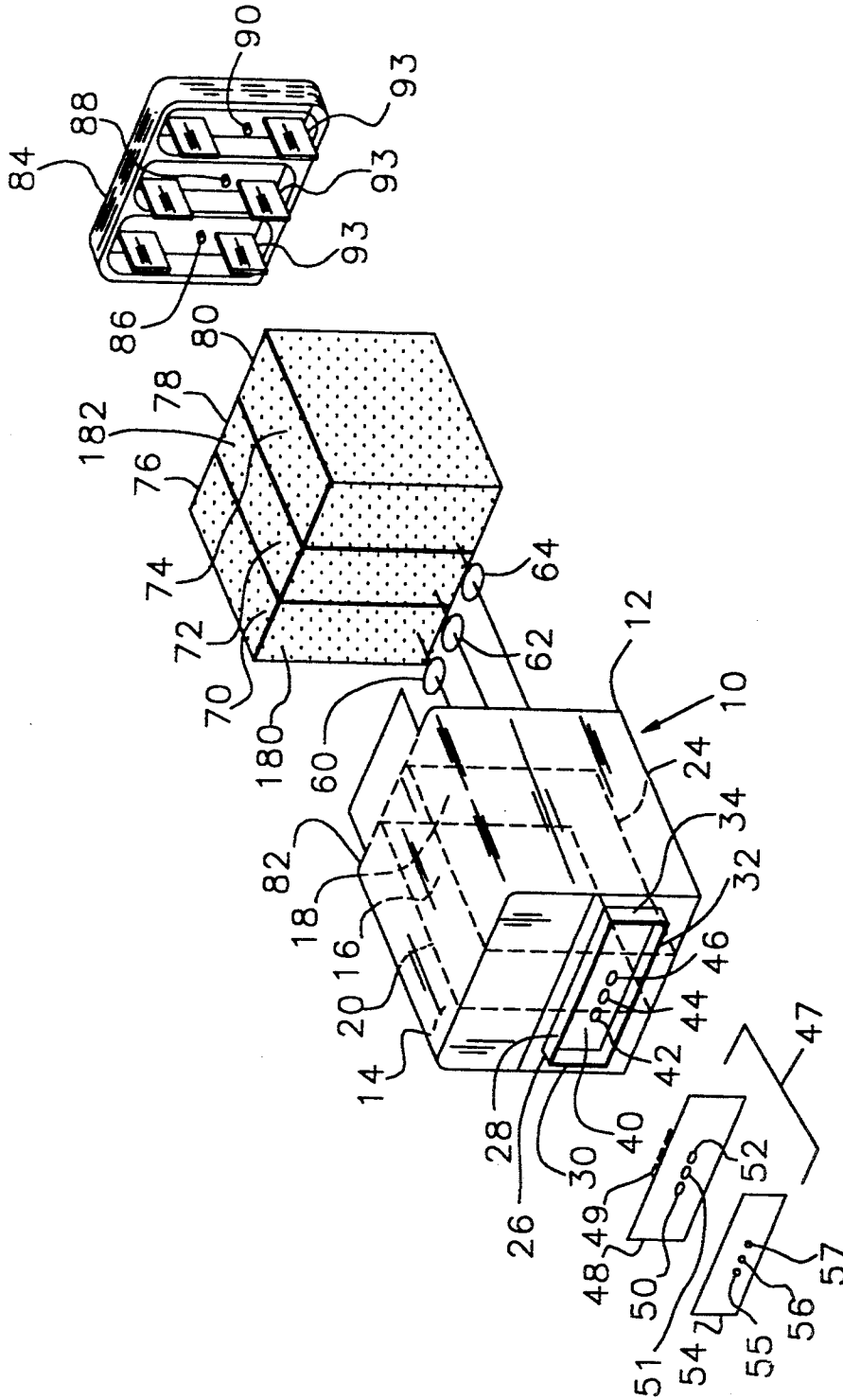


FIG. 1

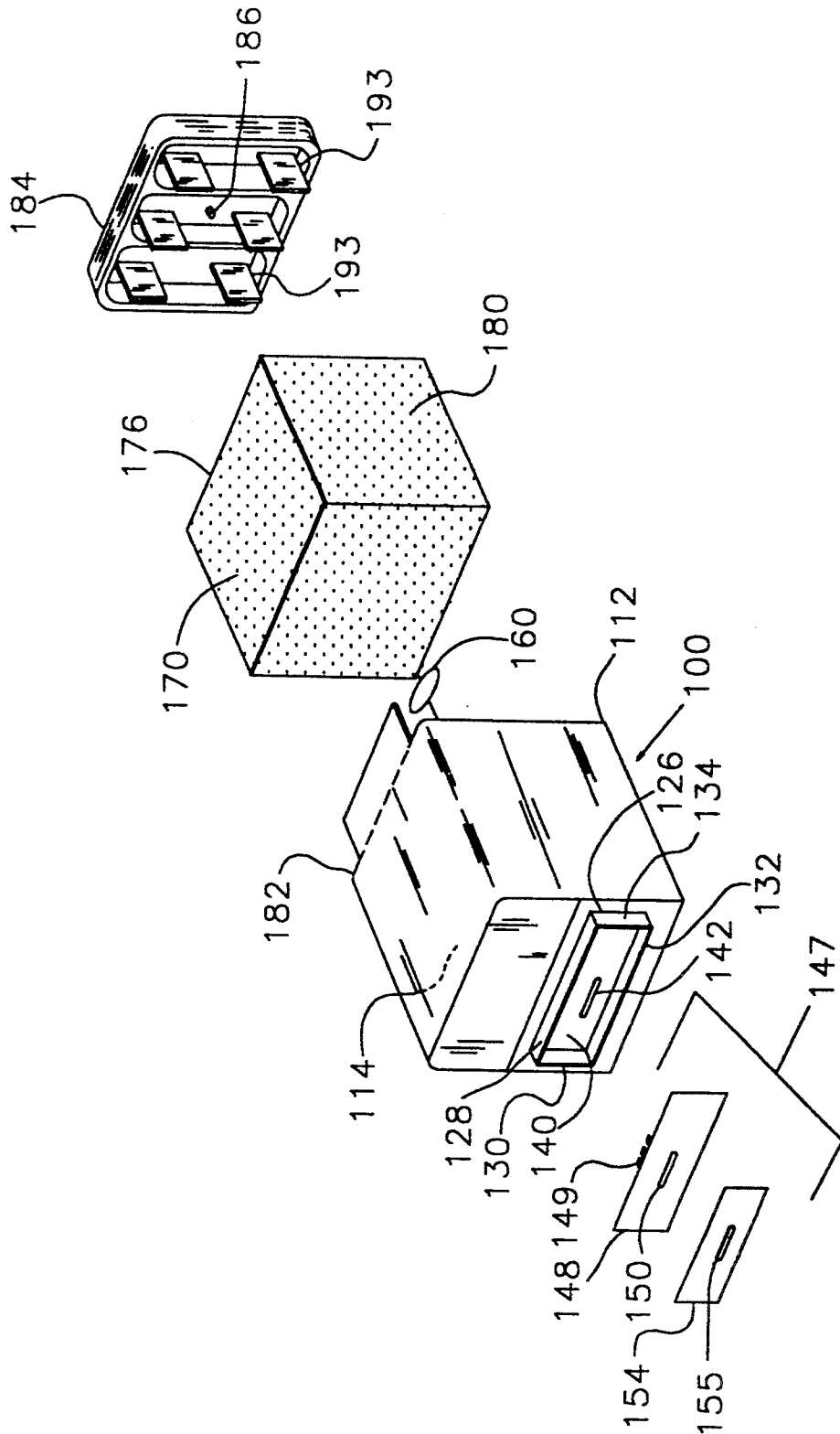


FIG. 2

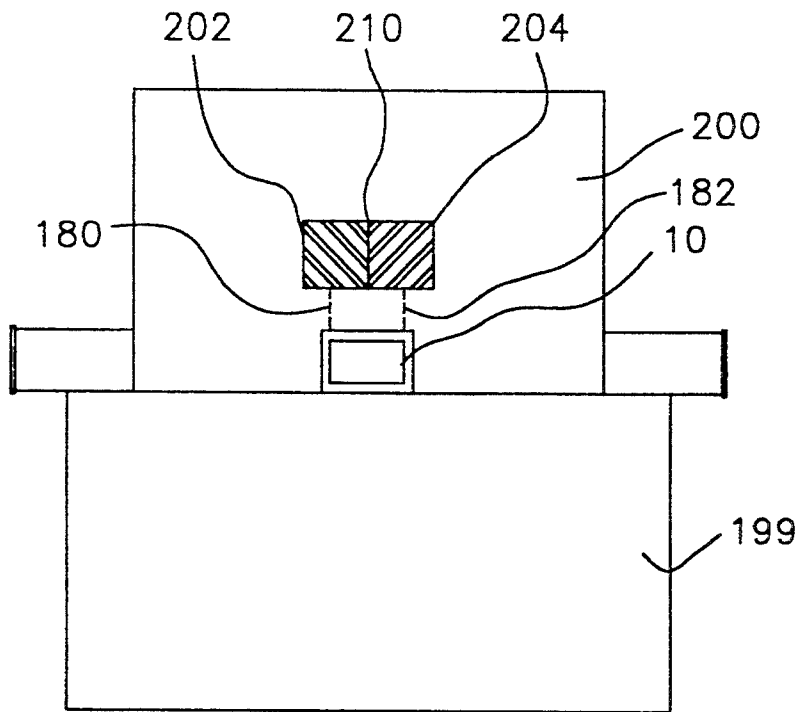


FIG. 3

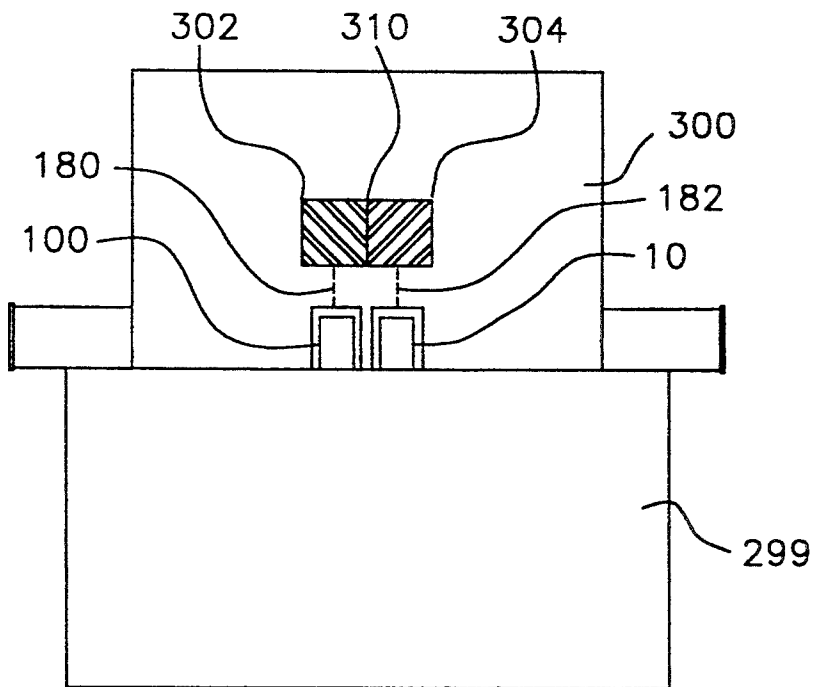


FIG. 4

METHOD AND APPARATUS FOR PREVENTING COLOR BLEED IN A MULTI-INK PRINTING SYSTEM

BACKGROUND OF THE INVENTION

The present invention generally relates to thermal inkjet printing technology, and more particularly to a multi-color thermal inkjet printing system in which color bleed problems between adjacent printed regions are controlled.

Substantial developments have been made in the field of electronic printing technology. Specifically, a wide variety of highly efficient printing systems currently exist which are capable of dispensing ink in a rapid and accurate manner. Thermal inkjet systems are especially important in this regard. Thermal inkjet systems basically involve a cartridge which includes at least one ink reservoir/compartment in fluid communication with a substrate having a plurality of resistors thereon. Selective activation of the resistors causes thermal excitation of the ink and expulsion thereof from the ink cartridge. Representative thermal inkjet systems are discussed in U.S. Pat. No. 4,500,895 to Buck et al.; No. 4,794,409 to Cowger et al.; and the *Hewlett-Packard Journal*, Vol. 39, No. 4 (August 1988), all of which are incorporated herein by reference.

Recently, additional developments have been made in the field of thermal inkjet technology involving the generation of multi-colored images. This is typically accomplished through the use of specially-designed thermal inkjet cartridges having a plurality of individual ink compartments therein. Each of the compartments is designed to retain a selected ink having specific physical/color characteristics. By combining these ink materials on a substrate (e.g. paper) in varying configurations and quantities, multi-colored images having a high degree of print resolution and clarity may be produced. Exemplary thermal inkjet cartridges having multiple ink-containing compartments are illustrated and described in U.S. Pat. No. 4,771,295 to Baker et. al. and U.S. Pat. No. 5,025,271 to Baker et. al. which are both incorporated herein by reference.

However, under certain circumstances, a significant problem can occur when multi-color images are printed using thermal inkjet technology as described above. Specifically, this problem involves a situation known as "color bleed". In general and for the purposes set forth herein, color bleed is a term used to describe the diffusion/mixture of at least two different colored ink regions into each other. Such diffusion/mixture normally occurs when the different colored regions are printed next to and in contact with each other (e.g. at their marginal edges). For example, if a region consisting of a first coloring agent (e.g. black) is printed directly adjacent to and against another region consisting of a second coloring agent (e.g. yellow), the first coloring agent will often diffuse or "bleed" into the second coloring agent, with the second coloring agent possibly bleeding into the first coloring agent. Accordingly, indistinct images with a poor degree of resolution are produced. An insufficient degree of resolution results from the production of jagged, nonlinear lines of demarcation between adjacent colored regions instead of sharp borders therebetween. This can create significant problems, especially when high volume printing systems are

In addition, color bleed problems in multi-ink systems are also caused by strong capillary forces generated in many commonly-used paper substrates. These capillary forces cause a "wicking" effect in which coloring agents are drawn into each other by capillary action through the fibers of the paper materials. This situation also results in a final printed image of poor quality and definition.

The present invention represents a unique and highly effective approach in the control of color bleed in multi-color thermal inkjet printing systems. The methods described herein may be implemented at a minimal cost, and do not require the use of extra equipment, custom manufactured paper, and/or special paper coatings. The present invention therefore represents an advance in the art of thermal inkjet printing technology as described in greater detail below.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved multi-color thermal inkjet printing system.

It is another object of the invention to provide an improved multi-color thermal inkjet printing system which uses a plurality of colored ink materials to produce multi-color images.

It is another object of the invention to provide an improved multi-color thermal inkjet printing system which avoids problems associated with color bleed between adjacent printed regions.

It is a further object of the invention to provide an improved multi-color thermal inkjet printing system which avoids problems associated with color bleed through the use of specially formulated ink materials in which the coloring agents therein do not migrate into each other after printing.

It is a still further object of the invention to provide an improved multi-color thermal inkjet printing system which avoids problems associated with color bleed through the use of specially-formulated ink materials which are manufactured and used in an economical and highly effective manner.

It is an even further object of the invention to provide an improved multi-color thermal inkjet printing system which effectively avoids problems associated with color bleed without the use of extra equipment, custom-manufactured paper, and/or special paper coatings.

In accordance with the foregoing objects, the present invention involves a highly efficient thermal inkjet printing system which is capable of generating multi-color images on a substrate (e.g. paper) without color bleed between adjacent color regions. As indicated above, color bleed involves a situation in which the migration of coloring agents occurs between adjacent printed regions on a substrate. Color bleed substantially decreases print quality and resolution, and prevents distinct boundaries from being produced between adjacent color regions.

The invention as described herein is especially suitable for use in thermal inkjet and other printing systems which include multiple cartridges, with each cartridge having one or more different color ink materials therein. In addition, the invention is also suitable for use in connection with specially designed ink cartridges (described below) which each include a plurality of compartments that are designed to retain a different color ink therein. In many instances, each individual cartridge will contain separate supplies of cyan, yellow, and/or

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