PROGRAMMED AND COMPLEMENTARY COLOR REDUCTION

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Abstract: The renewed color separation technique of using black ink instead of the minimum portion of chromatic inks not only for neutral tones but also for all tertiary colors is explained. The main advantages for the printer as well as the trade shop are stability and larger tolerance ranges within the press run. Reproduction with the CCR-method of reducing complementary colors down to the extreme "achromatic reproduction" are demonstrated. An overview is given for getting such separation sets by standardized procedures in the Hell scanners today and with an improved color computer for the Chromagraph 399 ER or by digital color transformations, i. e. PCR within the Chromacom system. The PCR transformation values are precalculated with respect to the printing ink, paper and press process parameters on a colormetric basis. Same PCR data can be used within a retrofit kit for the new laser scanners which will be available October 1984.

Improvements with higher color reduction

Which are today's and future possibilities for "improved UCR-methods" as achromatic reproduction or PCR? This paper will provide an overview for these separation technics of using black ink instead of the third chromatic ink not only for neutral tones but for all colors printed with 3 chromatic inks. The old and some new arguments for separations with high color reduction have been discussed very often at all events in Europe during the

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last year - especially in Germany. A lot of papers are published, some research work is done. Therefore I may concentrate on a short summary:

The main advantages with the reduction of chromatic ink(s) together with the necessary increase in black ink are:

- Increased tolerance ranges for process ink balance and register in the press for chromatic inks

- Increased color reproduction stability in gray tones and colors with high neutral components

- better detail resolution

- Printing ink consumption savings

- Improved drying characteristics and better print yield

Despite the very substantial advantages some disadvantages are still present today:

- Unusual look of color separation sets and subsequent difficulties in dot etching and correction

- Easier recognition of (screen) structure in the 4-color overprint

For a better understanding it is necessary to explain shortly existing definitions and to supplement these by the new comprehensive term "CCR" - which stands for complementary color reduction.

Basics of color reproduction

For any reproduction work the operator has to take care of two main functions:

- True reproduction of a color original (in general an increase in color saturation is desired)

- Manipulation for fulfilling special customer requirements

The color values of the original based on red, green and blue filter signals of the scanning unit are processed with the high flexibility of the color computer in order to get the required separation set. The prerequisite is the knowledge of the printing process supported by visual aids as printing scales and color charts.

To generalize, this reproduction is a transformation of the 3-dimensional color scan information into a number of color printing values which in consideration of the different printing processes has to be modulated in such a way as to assure the desired color reproduction. In this context it is unimportant whether printing is accomplished with 3, 4, or 6 inks. Because of economic conditions a 4-color approach with the 3 chromatic inks Y, M, C, and with the achromatic ink black is dominant.

The advantages of improved reproduction methods by increasing the black ink and reducing parts of the chromatic inks were recognized early on (see: Yule, ...) and were studied fundamentally by Hell Company, too. The idealized concept of simple subtraction of the minimum color part of any 3chromatic ink-overprints and substitution by black ink did not provide the correct result. It became apparent that dominant inks for a color value, (i. e. yellow and magenta for brown) had to be largely maintained to secure the desired color mixture.

This experimentally confirmed behaviour changes - non-unexpectedly - the closer one comes into the region of neutral tones.

But even here the 3 color ink values are not reduced equally - but rather in different amounts in relation to the printing gray balance.

Definitions

Chromatic reproduction

Is equivalent to today's conventional color separation set in which the gray scale is reproduced through the primaries Y, M, C. A skeleton black supports the modulation and picture contrast.

Total ink coverage

Is defined as the addition of the effective dot area of all process inks for a specific pixel in a halftone print. It is well suited to describe different reproduction variants as chromatic-, UCR-, achromatic reproduction if, in addition one specifies in which part of the picture or for what color mixture it applies. Today almost all values relate to neutral shadow (e. g. 370 percent total ink coverage).

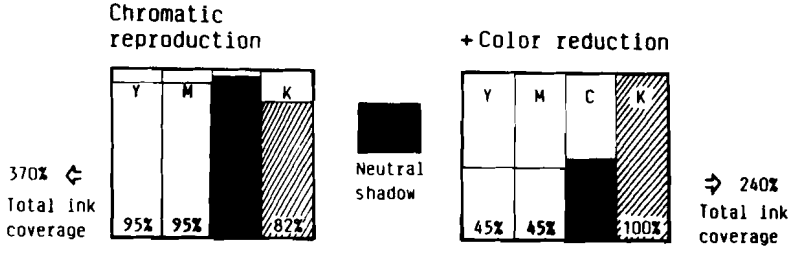


Figure 1

Under Color Removal, UCR

UCR is an adjustable color reduction to minimize trapping and other problems during the press run - especially in wet to wet printing for 3- or 4-color overprints. The maximum effect of UCR-controls is in the shadow and the gray axis. However, a sharply defined effect for neutral tones only is not desireable, if one wants to avoid harsh breaks. Therefore a smooth transition from the gray axis into the color space is necessary.

The allowable degree of UCR (e. g. 60 percent) and therewith the rest of the chromatic inks in the shadow (e. g. 40 percent dot size for Y, M, C) depends mainly on the final print density of the black ink.

Gray stabilization

This is a method introduced by F. Brunner, 1977, in which all gray tones from highlight to shadow are reproduced totally or partially with the black ink. Gray stabilization within the Chromagraph scanners is used frequently with the UCR-controls when setting the starting point into highlight.

Under Color Addition, UCA

UCA has the inverse function to under color removal and with the same effective field as UCR, i. e. in the gray axis and a small surrounding area. Up to now the scanning adjustments have been used to manipulate color casts in shadows.

In connection with CCR and achromatic reproduction the addition of the chromatic inks Y, M, C under solid black ink can be adjusted by UCA-controls to secure proper shadow density. Typical values for a normal black ink are 50 percent dot size for Y, M, C.

Achromatic reproduction (Achromatic Synthesis)

This word (and the corresponding German "Unbuntaufbau") caused a lot of misunderstandings, mainly because the association "achromatic = no color" - leads to prejudices against this approach, while results show an improvement in color print quality. The achromatic or neutral component of a printed color is that part which is darkening the color resulting from the overprint of all 3 chromatic inks. This gray component is replaced by the appropriate amount of the achromatic black ink for all colors within the whole color space. The term "achromatic reproduction or synthesis" should be used only for the total removal of darkening inks, that is the complete reduction of the ink(s) with the lowest portion(s). Depending on the printed color one or two chromatic inks are afflicted. For neutral tones all 3 chromatic inks are removed totally.

For all reproduction work with intermediate stages between chromatic and the extreme achromatic reproduction - selectable by the customer, it is necessary to introduce a new definition:

Complementary Color Reduction, CCR

CCR is the method for adjustable or selectable reduction of chromatic inks in the whole color space in respect to customer conditions. With this approach the complementary inks in a 3-color overprint - responsible for the gray portion of a printed color - will be partially reduced or totally removed. Simultaneously the automatic increase of black ink is carried out. A corresponding change of the other chromatic ink portions causes equivalence in line and saturation to the original color.

Complementary color reduction: CCR

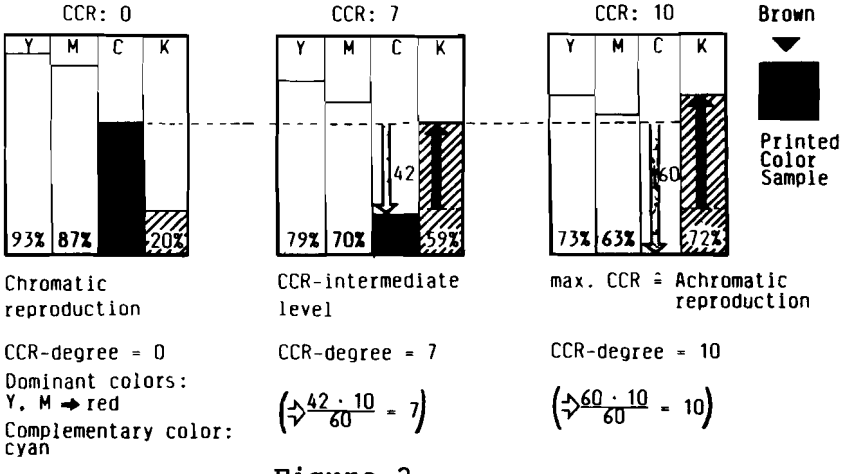


Figure 2

For scaling of CCR we use a number between 0 and 10. For maximal degree 10 we get an achromatic reproduction (CCR-degree: the difference of the complementary color signal related to the original complementary color signal and multiplied by 10).

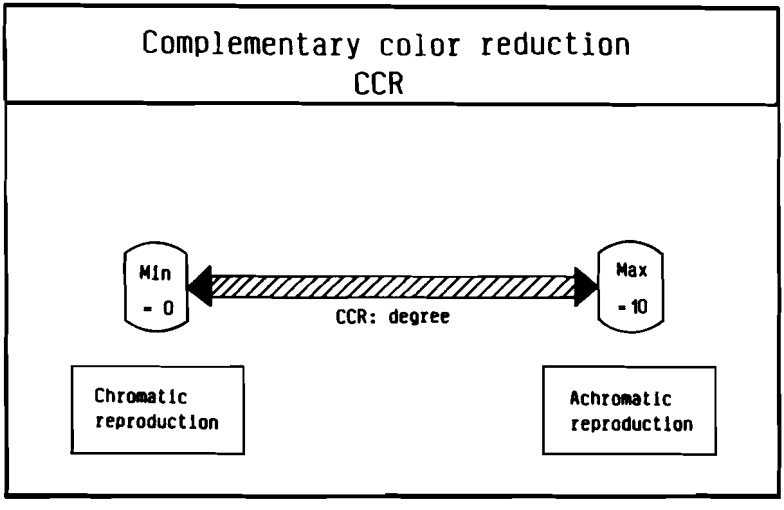


Figure 3

The typical curves in Fig. 4 demonstrate the reduction effects for neutral tones: dotted lines are the neutral gradations of cyan and black for normal reproduction, the other lines are the same for achromatic reproduction - including under color addition of 50 percent for cyan.

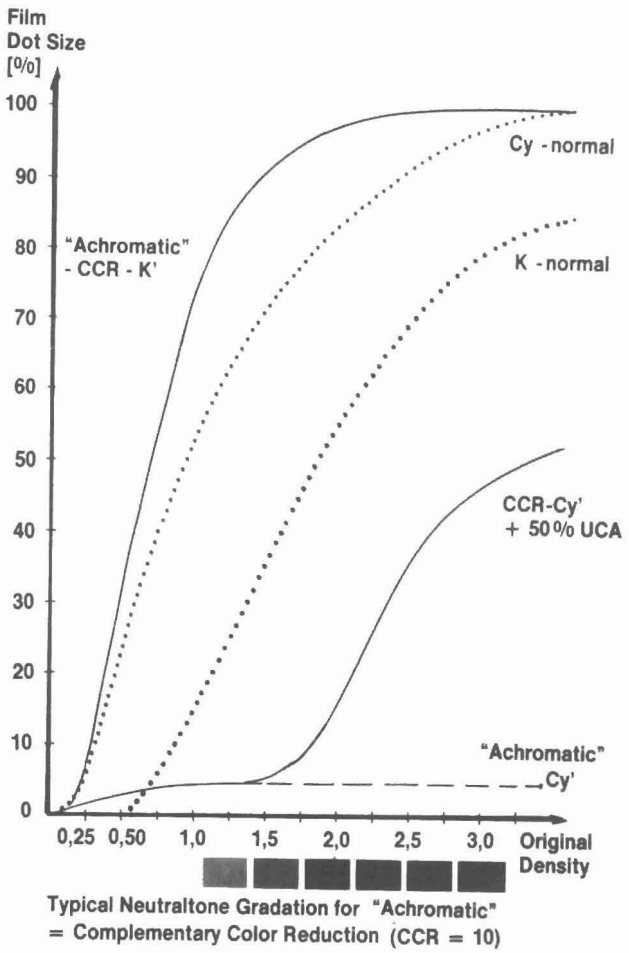


Figure 4

Important are also curves for color wedges from a clean, saturated color to the shadow. Fig. 5 shows the changement of cyan, small reduction of the dominant colors yellow/ magenta and increase of black for red/brown-wedge and for the extreme complementary color reduction (CCR-degree: 10) with UCA = 50 percent.

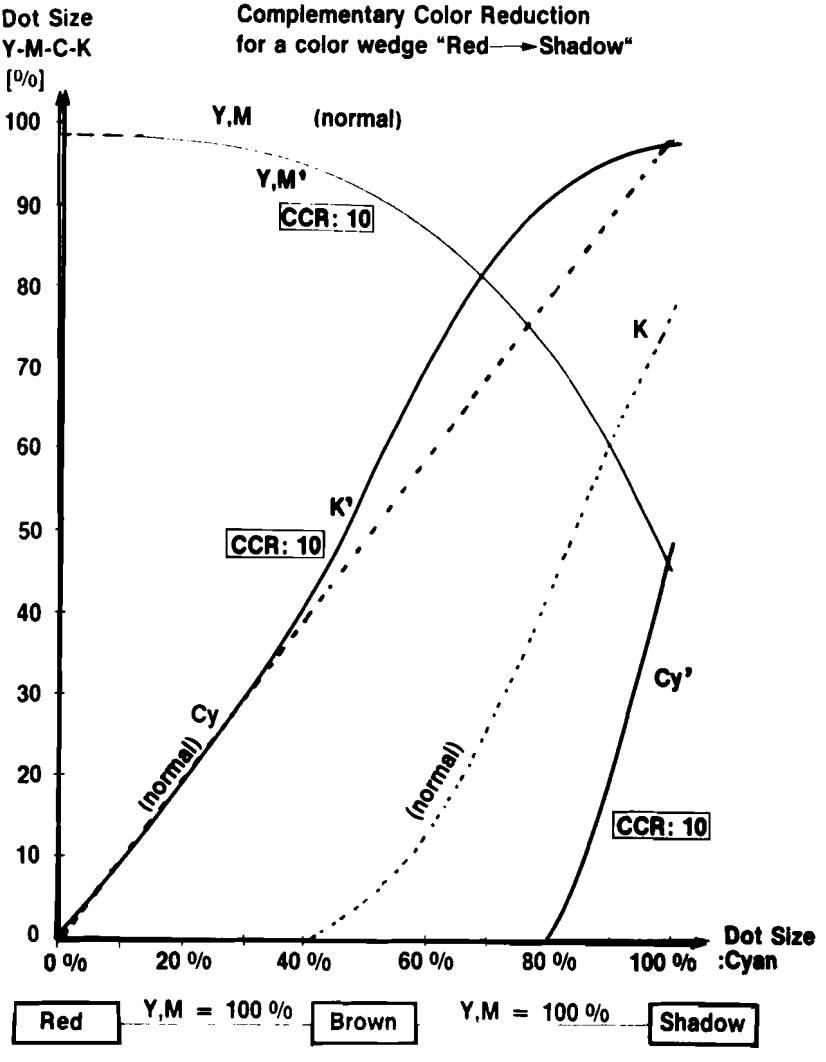


Figure 5

Instead of the extreme removal of darkening inks it is useful to reduce down to 5 percent - 20 percent dot size in order to get smooth transitions and correction reserve in the separation film.

Programmed Color Reduction, PCR

PCR is the method for complementary color reduction via precalculated color transformation tables. Here the operator adjusts the color computer in a conventional way for a chromatic reproduction. The transformation for selectable CCR-levels is then carried out fully automatically with a hardware extension for scanners or a software solution for electronic page make-up. In calculating the transformation tables print and press specific values as well as color mixtures based on colormetric principles are taken into consideration.

Color reduction in Hell machines and systems

Machine	Brief description
DC 350 CP 340 CP 341	Analog color computer with gradation selector, black computer and stored gradations
C 399	New analog color computer
C 399 ER	Improved analog 399-color computer with CCR and special UCA
Chromacom	Software calculation of PCR transformation
DC 350 ER CP 340 ER CP 341 ER C 399 ER	Digital PCR extension

Figure 6

Chromagraph Scanners DC 350, CP 340, CP 341

These scanners have the possibility of separately controlling the neutral/white-color-gradation from the black color gradation. In addition the "dirty-colors"-controls - already present in older scanners - are used to maintain dominant colors. Together with the selective color correction - which supports strong white color correction - complementary color reduction up to the achromatic reproduction can be realized. Additional recommendations and data for a special programmable achromatic black gradation are made available through special instructions for the scanner operators. By adjusting the UCR controls the total ink coverage to the desired end density is accomplished.

Chromagraph 399

With the new color computer of the 399 similar good results can be obtained with help of a user set-up recommendation. An automatic increase of the black separation signal after use of the UCR-controls improves operator handling.

For achromatic set-up at the a/m scanners a different approach as well as some training will be necessary. Experience has shown that this can be accomplished in a relatively short time period.

Complementary Color Reduction with the 399 ER

Additional improvements of the color computer allow production of separation sets in all intermediate steps of complementary color reduction up to an achromatic set, together with easy handling. Starting from a conventional color separation set the following operator control elements will be utilized:

1 CCR-Switch (on/off)

1 CCR-Control (maximum set up results in achromatic reproduction)

2 UCA-Controls (starting point and intensity) with fixed positions depending on the black ink.

The automatic increase in black in conjunction with the dominant color controls assures good color reproduction agreement between conventional and CCR-color sets in printing. Adaptations for originals with critically heavy color casts can be accomplished without any restriction.

Programmed Color Reduction: PCR

A totally different approach is the PCR transformation in which the operator continues to set up the color reproduction in a conventional manner. In a subsequent step the transformation of primary signals take place automatically based on the customer's requirements for CCR: degree which is input via a code number.

A significant advantage is that all printing specific data such as ink, paper, dot-gain (for offset), or printing gradation (for gravure), gray balance have been measured on a test color chart before by spectrophotometric means. These data are taken for calculation of complete color space tables in which the rules of color mixture for the printing process as well as the selected CCR:degree will heavily influence the transformation. Result of this calculation are new separation values (Y',M',C',K') that correspond to each chromatic color mixture (Y,M,C,K) by an optimized colormetric approximation. An important prerequisite for this method is a standardized print of proof process that is controlled on reproducibility within normal tolerances.

The calculation algorithm automatically assures that, for example, with a normal black ink one requires approximately 50 percent effective dot area for the chromatic inks in order to get maximum print density; while a 3/4-tone requires only 5 percent dot size for Y',M',C'. A practice oriented reduction of the darkening chromatic ink(s) to a level of 5 - 20 percent dot size in the separation film for colors outside the neutral area is programmable. With normal black ink total ink coverage of 200 percent - 250 percent for a neutral shadow result.

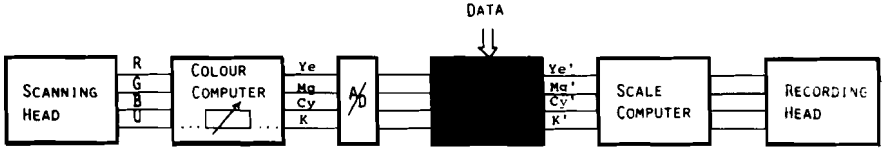
The calculated color space transformations are stored on floppy disk and can be used in the following two ways:

PCR-Software within the Chromacom System

By using a specialized software single pictures as well as completely finished pages can be transformed from a chromatic set into a selectable CCR: degree within the Chromacom system. Since this transformation requires data processing time, this function today is used primarily for tests and special applications. In future the fast array processor BSP 11 will speed up these transformations.

PCR-Hardware Set for Scanners

The PCR-extension will be available for the new laser scanners DC 350, CP 340, 341 and C 399 ER as a retrofit kit October 1984. The transformation of the separation signals (Y,M,C,K) adjusted in chromatic reproduction - to the new values with complementary color reduction (Y',M',C',K') occurs on line. There is no time-loss and no need for additional operator judgement. After the data have been loaded, the selection of the CCR:degree is done by a code number.



Signal path in a color scanner with PCR Extension

Figure 7

In general the possibilities of the PCR-extension for additional applications of digitally stored transformation will gain more importance for the future.

Literature

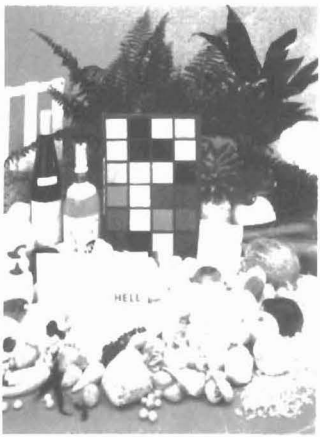
A. Burckhardt; u. a. Polygraph 2, 1983
E. Hennig; Polygraph Jahrbuch 1967, Frankfurt/M.
H. Küppers; u. a. BVD-Publication III, 1983
I. Pobbaravsky; Ph.Sc.a.Eng, Vol.8, No. 3, 5.1964
K. A. Springstein; Polygraph 11, 1973
J. A. C. Yule; Principles of Color Reproduction, Wiley (p. 294 ff)

Illustration: CCR/UCR
Separation films for cyan ink

Standard

CCR: 10 UCA - 50%

UCR: 50%



CCR: 6 UCA - 30%

Figure 8

Illustration: CCR/UCR
Separation films for black ink

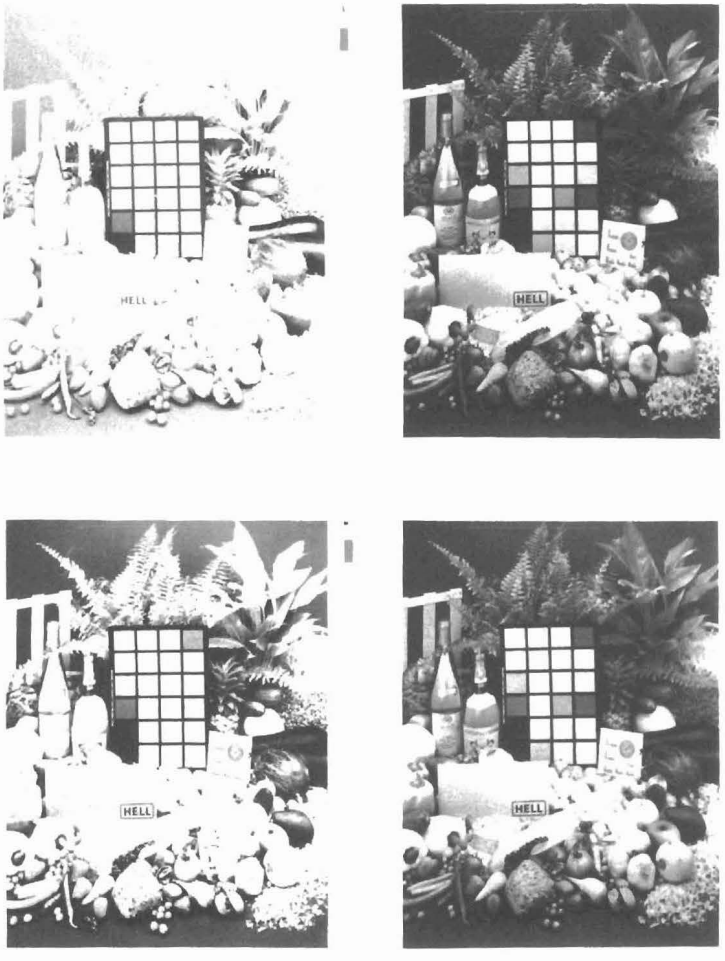


Figure 9