INVESTIGATION INTO THE APPLICATION OF ACHROMATIC SYNTHESIS TO THE PRINTING INDUSTRY

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1. Abstract

Achromatic Synthesis, which comes from the German word Unbunt-Aufbau is now becoming well known in the Printing Industry and is being well received although with some controversy in relation to PCR, ICR, CCR, UCA, UCR digital and analogue. It has been predicted that within three years 80% of the Printing Industry will be printing Achromatic.

However, this theory has been with us for some 30 years but it is only now becoming a practical proposition for the industry.

Tobias[1] in TAGA 1954 stated that "any colour within the gamut of the four-colour process printing inks can be reproduced by pairs of the chromatic inks plus black. The chromaticity of a colour will vary with the two chromatic ink mixtures, whereas luminance is affected by the amount of black used".

Yule[2,3] in his book in 1967 mentioned the black printer and UCR followed by Fuchs[4] who stated that the concept had been practised over 20 years ago at Sun Printers, England in Gravure for speciality jobs such as atlases.

The Black Printer is considered to be the backbone of the theory and its importance will be analysed plus an overviewing of the application of the theory in Europe by Harold Küppers.[5,6]

Advantages and Disadvantages to the Printing Industry especially in reducing the impact of some of the printing problems such as dot gain, ink trapping etc. which effect the printed results and reducing the numerous variables in the printing industry by making them manageable, will be emphasised as mentioned in TAGA '82[7]

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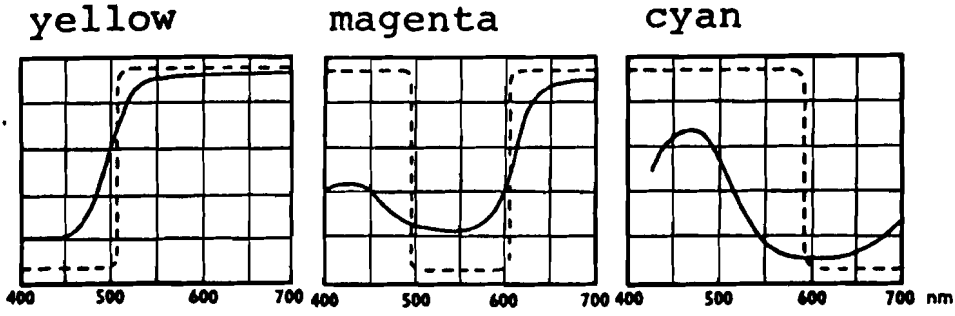
2. Theory

The final aim of the Printing Industry is to match the coloured original as closely as possible. Conventionally, this was achieved, first by printing three subtractive primaries, yellow, magenta and cyan (chromatic). The overprint of these three coloured inks cannot produce a satisfactory black because they contain unwanted absorptions and thus have no ideal spectral curves. As known, and shown in Figure 1 below.



Real process ink reflection ————————

Ideal process ink reflection - - - - - -

FIGURE (1) shows the spectral sensitivity of real inks

Therefore the conventional black ink was introduced as a key to give neutrality and depth of colour.

Improvement was also shown by using the Under Colour Removal (UCR) and full black to extend the gamut of colour in the dark areas and replacing yellow, magenta and cyan in the shadow areas.

This also solved ink trapping and some colour ink consumption. However, UCR was limited to neutral only because it was impossible on a camera to produce a full range UCR and the black positive was generally used to make the UCR mask.

The Achromatic Theory of colour reproduction is based on the concept that it is unnecessary to use three chromatic inks (Yellow, Magenta and Cyan) to produce a neutral component or value which could be obtained by using appropriate proportions of black.

Figure 2 shows that the overprint of Yellow, Magenta and Cyan in different percentages will produce two separate componenta.

1. Colour components "value" which could consist of one colour or two fundamental colours.

2. Black components (neutral value) which consist of equal amounts of Yellow, Magenta and Cyan.

These components neutralise each other, lose their chromatic form and therefore appear achromatic or neutral.

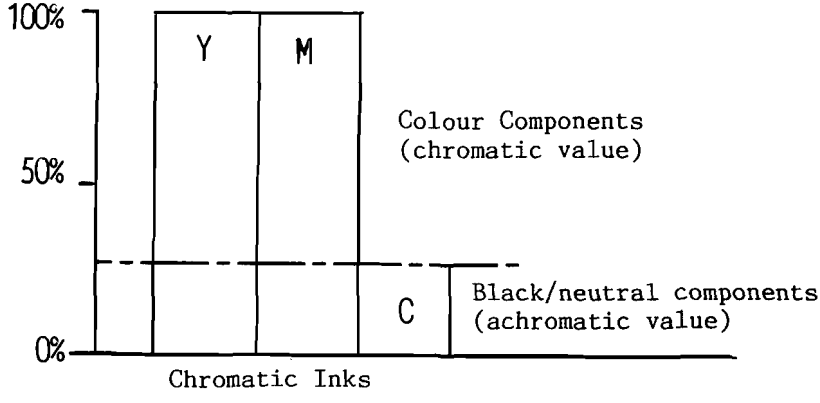


FIGURE (2)

The idea is to remove the colour ink contributing the lowest portion which is responsible for darkening the hue of the printed colour which will be replaced by a computed value of black, such as the removal of

Cyan, 3rd least ink printed over Yellow and Magenta
Magenta, 3rd least ink printed over Yellow and Cyan
Yellow, 3rd least ink printed over Cyan and Magenta

The black, in this theory replaced the colour inks in the shadow areas as well as replacing the third colour in any two-colour areas as follows:-

i) in the brown area this is achieved by printing yellow and magenta only with black superimposed, this is replacing the conventional cyan.

ii) in the green area this is achieved by printing yellow and cyan only with black superimposed, this is replacing the conventional Magenta

iii) in the blue (violet area) this is achieved by printing yellow and magenta only with black superimposed, this is replacing the conventional cyan.

All colours in a final printed result will be produced by a combination of one or two of the chromatic inks, Y,M,C plus black as in Figure (3).

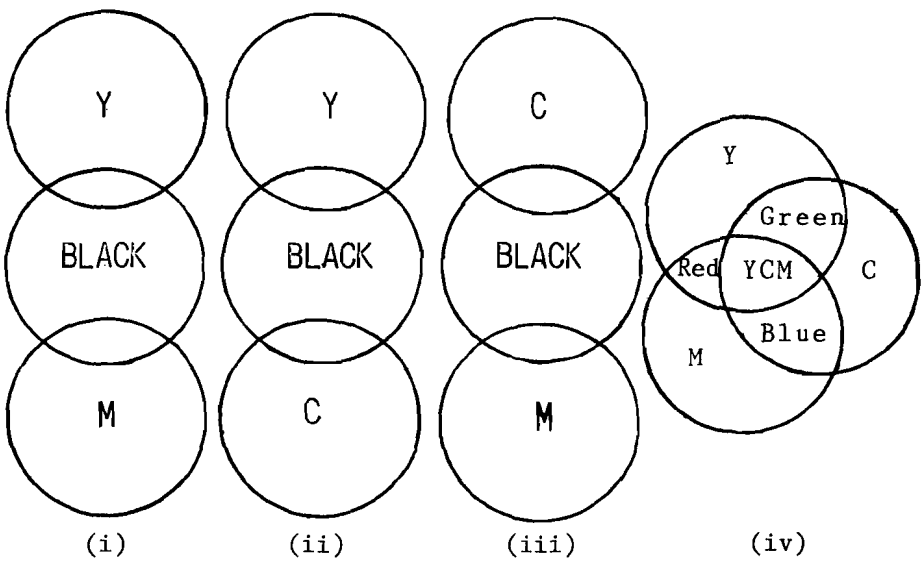


FIGURE (3) Achromatic Theory and Conventional Printing

The Achromatic theory has been explained by the German colour theorist, Harold Kuppers[8] as follows:-

"There is in printing terms no need to darken or degrade a tertiary colour hue with a colour ink. Black can do it just as well by replacing one of the three primaries, namely the one that contributes least to producing a colour hue". As illustrated in Figure 4a and 4b.

However, it is not possible to apply a perfect colour theory to non perfect inks. Therefore, if we follow the theory with the real practical ink ie. substituting the 50% Magenta (Figure 4a) with 50% black (Figure 4b) this would produce a greenish tinge with a yellow tinge as shown visually in the colour atlas page 79, whereas in fact, our original colour in 4a is a brown with greenish tinge as shown in the Colour Atlas page 113.

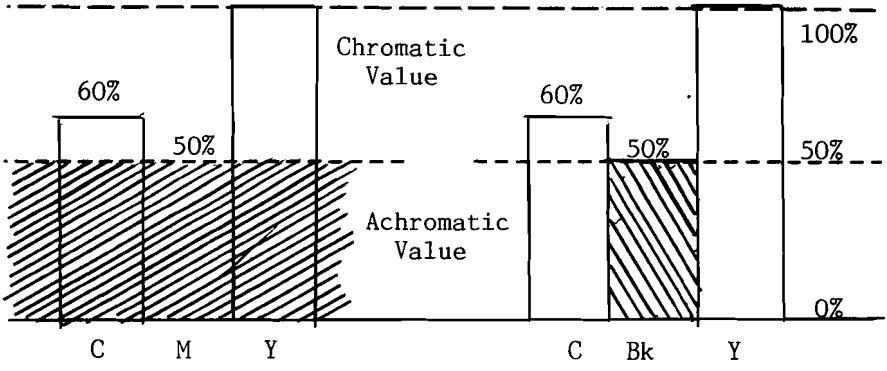


FIGURE 4(a)

FIGURE 4(b)

To match the Achromatic Synthesis correctly to chromatic results, using the real practical inks the black will substitute the cyan and not the magenta as in Figure 4C the yellow will drop to 80/90% the magenta 40% and the black will print 70% (confirmed by Colour Atlas page 59.)

Therefore, the readers attention is drawn to the fact that the Magenta has been replaced by black in theory but in practice the cyan has been dropped.

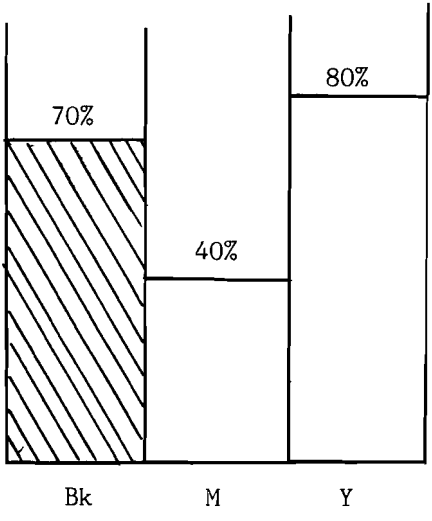


FIGURE 4(c)

This is due to the fact that the existing process chromatic inks, yellow, magenta, cyan contain unwanted colour absorption as indicated previously in Figure 1 and demonstrated in Figure 5 following.

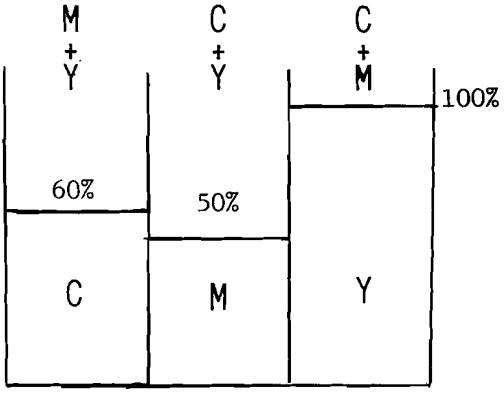


FIGURE 5a

The actual printing inks including the unwanted absorption

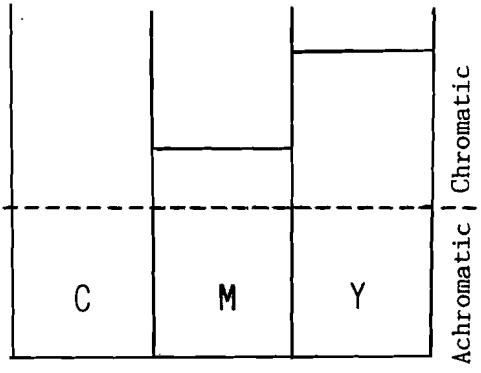


FIGURE 5b

The actual printing ink after allowing for the unwanted absorption

In Figure 5a

1. Cyan will contain some unwanted absorption of magenta and yellow.

2. Magenta will contain some unwanted absorption of cyan and yellow.

3. Yellow will contain some unwanted absorption of magenta and cyan.

In Figure 5b

By deducting the above unwanted colour absorption from the existing chromatic inks and adding these absorptions to their respective chromatic inks will result in cyan being the least tertiary colour.

3. Practical Benefit to the Printing Industry

There is no benefit to the Process House, all the advantages of Achromatic Synthesis are for the printer who can produce more effectively with his present machinery without investing in new equipment or technology. These advantages could be classified as:-

3.A Technical Benefit

1. Reduced sensitivity to colour inking fluctuations, therefore no colour fluctuations in the grey tones.

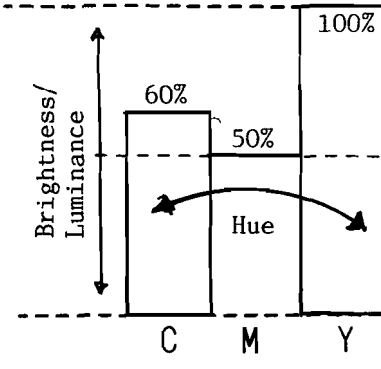


FIGURE (6a)

Brightness and hue fluctuations affected by the 3rd colour Magenta

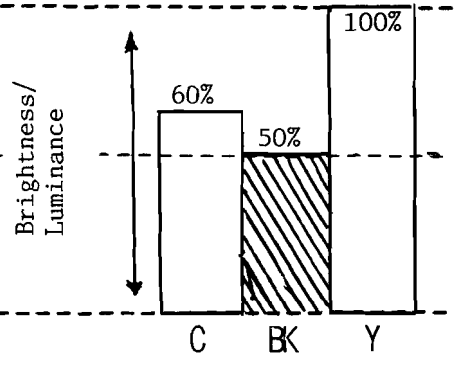


FIGURE (6b)

Fluctuations mainly in brightness

In Achromatic Synthesis theory the black printer plays a major role because it replaced the chromatic ink which is the main difference from the conventional printing where the tones are reproduced by using specific percentage of chromatic inks Y,M,C. Therefore the balance of the grey tone becomes critical throughout the printing run. This is because the Ink Film Thickness (IFT) and other variables lead to fluctuation on the press.

Using Achromatic separation the grey tones are reproduced mainly by the black printer. Therefore a tertiary colour tone (hue) is stabler in offset printing when this tone is degraded by the black printer rather than any other third chromatic ink. This is because the fluctuation in the black ink will effect only the brightness.[8] or luminance[1]. Thus it will lighten or darken the hue without effecting its chromatic value.

3.A Technical Benefit

2. Much higher ink weight can be printed, giving higher saturation of primary colour components, without fear of ink back transfer.

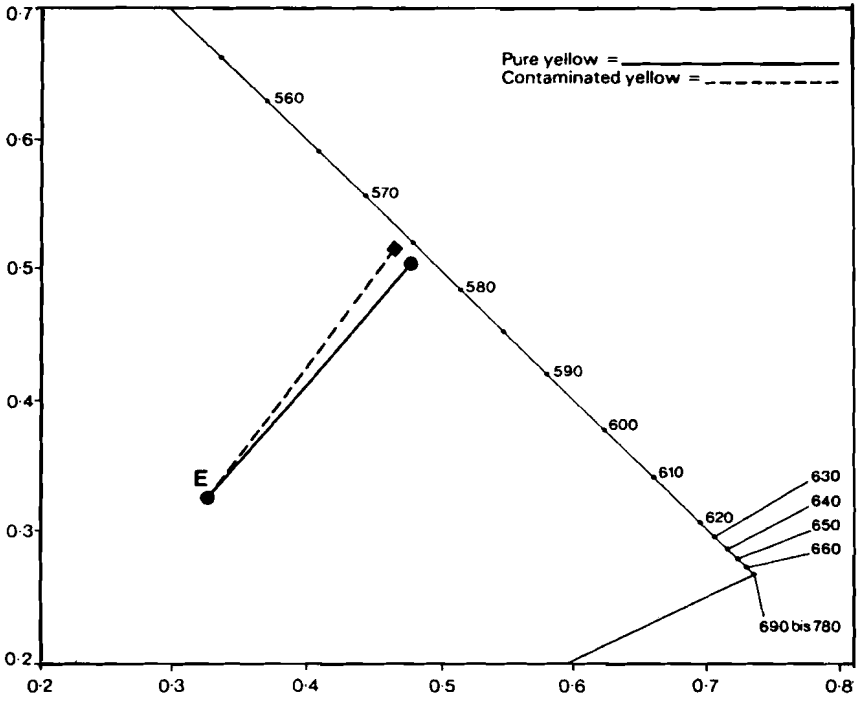


FIGURE 7 Colourmetric measurement of ink back transfer

In conventional printing Ink Film Thickness (IFT) - ink weight - has to be within limits where certain density tolerance has to be maintained otherwise ink back transfer will occur as shown in Figure 7 above where Yellow has been contaminated with cyan.(9)

In printing achromatic the ink weight can be increased without fear of this phenomena because ink weight only effects the saturation of primary colour components without effecting other areas because the reduction/removal of the complimentary colour has already taken place. Additionally the grey balance and shadows have been controlled by the black printer in the Achromatic colour separation.

3.A Technical Benefit

3. Better ink acceptance and less trapping problems

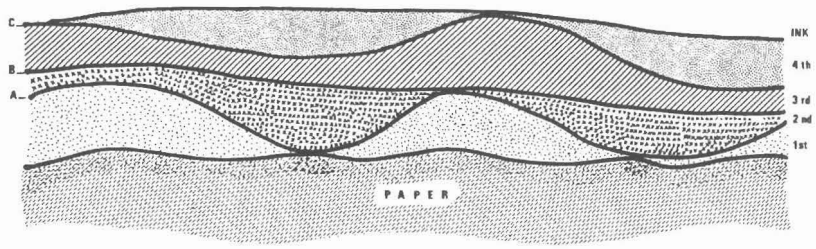


FIGURE 8a Four Ink Layers (WOW)

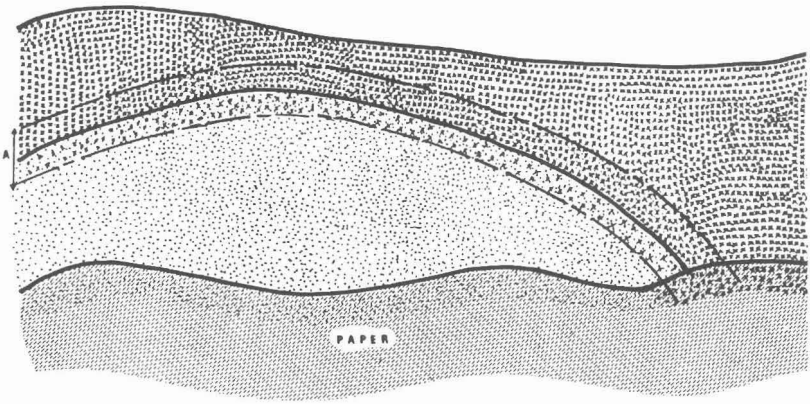


FIGURE 8b Enlarged Section of Two Ink Layers

The cross-section model 8a above illustrates a possible consequence of laying down four layers of printing ink in conventional printing which will result in severe ink trapping problems where the inter-zones A,B,C between the ink layers will produce a complex ink trapping behaviour as the layers will be printing wet-on-wet.

Figure 8b is an enlarged section where two chromatic inks are forming one inter-zone A where they meet and as both trap on dry paper the trapping problem is less severe as it is printing wet-on-dry.

In Achromatic there are only two chromatic inks plus black therefore there will be less trapping problems because maximum ink weight in any colour area is 240% instead of 360% (Cyan + Magenta + Yellow) + Black.

3.A Technical Benefit

4. Less dot gain problems

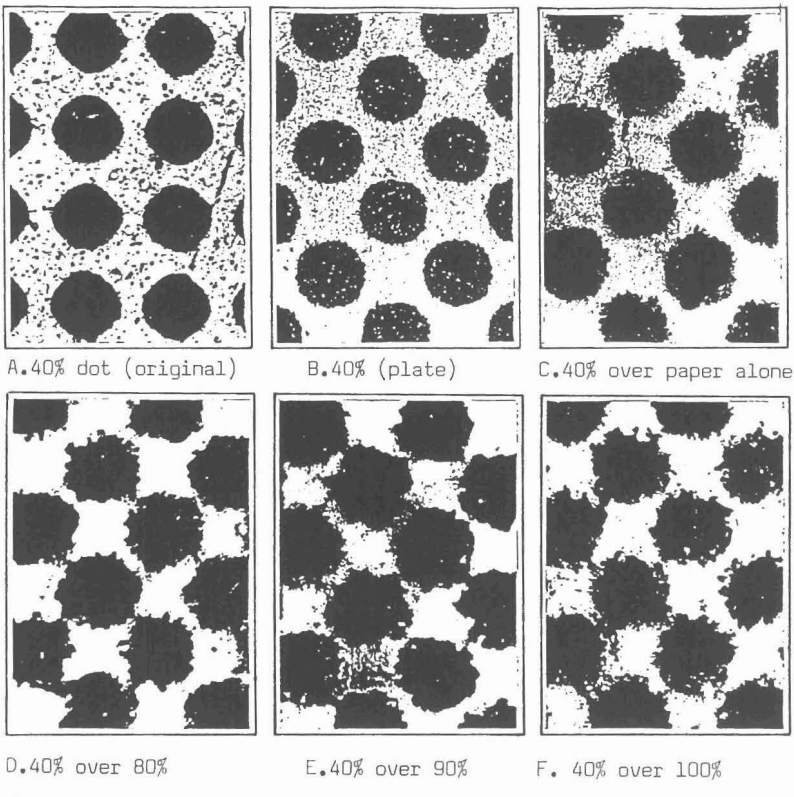


FIGURE 9 The effect of under colour on trapping, dot shape and gain.

It has been found that the dot gain problem has been affected by many variables such as intervals between impressions, ink back splitting, printing substrates, IFT, and colour sequence (under and over colour) as shown in Figure 9, especially when comparing the 40% original dot in A with the same dot printed over 90% under colour in E.

The dot gain phenomena has been born with the process due to the nature of transferring the printed image from one surface to another. Therefore it cannot be eliminated because it is an inherited part of the process.

It is obvious now from the Achromatic application that less chromatic ink will be printed and one ink will be eliminated. Therefore the problems associated with the variables listed above will be reduced and thus, this will reduce its impact on the dot gain phenomena. (10,11)

3.A Technical Benefit

5. Subjective judgement effect on quality control

The Achromatic Separation has an unaccustomed appearance. When the three colours are printed it gives a different image which takes away the printers personal interpretation and forces him to work towards specific densities. Although this may seem to be a disadvantage it does, in fact, ensure a consistent quality as it eliminates the human factor.

6. More precise colour rendering

7. More consistent reproduction through the whole printing run therefore more reliable running.(12)

8. Colour contrast sharpness and details, particularly in the shadow areas.

9. Less problems in the print finishing department ie. laminating, varnishing and binding. All are due to less use of spray powder on the sheet, thus producing brilliant results.

10. Better result in low quality paper.

3.B Cost Benefit

1. Reduce ink usage (consumption)

It has been claimed that in order to print Achromatic an absolutely neutral black would be necessary. This black should be deeper and have a different gradation than the currently available black.

However, from the authors research into the problem it has been found that this black would be impossible to produce because of sourcing of pigments and if a solution to this was found it would obviously be very expensive.

However, it is possible to produce a black to print Achromatic which would be denser than the ordinary black and contain a higher percentage of blue toner (generally reflex blue) and this would cost about 10%

Therefore as there would be a saving of 20-25% in chromatic ink the overall cost benefit would be in the region of say 10-15%. However, quantifying data is still in process.

3.B Cost Benefit

2. Less energy wasted in drying the ink

3. Faster speed on the press - higher productivity

4. Less set-up time (make ready). Therefore less waste and higher productivity

5. Using less and anti set-off powder (dusting)

6. Reduced drying problems

4.A Comment

The Printing Industry has benefited from the technical advancement in other areas ie. electronics, physics etc. and we now have the electronic page make-up, and the electronic scanner with laser dot generation which enables the industry to embark on Achromatic Synthesis. In the authors opinion this is a breakthrough not only in cost saving but from a technical point of view.

Therefore, with the support from manufacturers, trade houses and teachers we can start teaching our students in the colleges and institutions and invite personnel in the printing industry to see for themselves, practically, this new application.

4.B Method of Application

The Author feels that he should not comment on the method of application as the various companies such as HELL, DIANIPPON, CROSFIELD etc. naturally prefer their own systems.

1. HELL company call it PCR (Programme Colour Removal/ Reduction) also CCR (Complimentary Colour Removal/ Reduction.

2. CROSFIELD company call it Extended UCR (Under Colour Removal) or Polychromatic, emphasising their digital approach.

3. DIANIPPON company call it ICR (Integrated colour removal) emphasising their analogue approach.

Of course, there are other companies working in the field.

5. Further Work

Achromatic Synthesis has successfully been applied to offset and research has now commenced in Gravure:-

1. Black printer, gradation, range, density and pigmentation in relation to the poor quality paper and gloss in the Gravure Process.

2. The depth, size, and shape of Gravure cells with the application of Electrostatics to assist in transferring the full ink in order to achieve the gloss and the required density.

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