COLORIMETRIC SPECIFICATION OF PRINTING INKS

by Tino Celio * and Fred Mast **

Abstract: With the advent of hand-held colorimeters based on spectrophotometry a new "dimension" concerning accuracy and flexibility has become available to graphic arts. Redefinition of LTF-Preucil`s parameters might lead to a practically more useful abridged characterisation for the optical quality of printing inks.

1. Introduction

Densitometry has been used ever since to describe inking in the printing industry. Among the attempts to use densitometry to define quality of printing inks (e.g. to compare different sets of inks) LTF-Preucil`s formulas (Preucil Taga 57) are probably the most known. (Fig.1).
Their main caracteristic is to provide a quality vector (g,h,e) of relative kind i.e independent from strenght H (or concentration) of the ink itself.
Although Preucil`s formulas have been implemented in some densitometers their practical use has been very limited.
Raisons hereto are manyfold:

- Density (because of filter width and dichroitic behaviour of inks) is not proportional to concentration of ink, thus impairing the most appealing property of the relations ships
- Results do not coincide with eye`s judgement (a fundamental difficulty when using densitometry).
- Strong dependance from densitometer`s brand (due to difference in filters and in suppression of first surface reflections).

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2. The problem

To be colorimetrically suited for printing a set of inks must fullfil many requirements, the most importants beeing:

- be able to produce gray and almost black at higher densities
- cover the largest possible volume in the color space
- produce a tonal scale as linear as possible with concentration (or film thickness) to make prepress operation (i.e. masking) possible and simple.

Keeping additionally in mind that printing is an interaction of additive (highlights and middle tones) and subtractive (shadows) color mixture, it is clear that definition of printing inks implies standardisation of their spectral characteristics (Fig.2,3,4).
Such a procedure is cumbersome and has furthermore the disadvantage to unnecessarily limit the field of action of the chemical research engineeer.

It is better that standardisation concernes only the printed product. Indication of the boundary in a uniform color space (Fig.5) gives good insights in quality because it describes not only primary (c,m,y) but also secondary mixtures (r,g,b). Additionally indications of the tonal behaviour (i.e. variation in concentration) ist necessary (Fig.6) which might differe stronghy (up to 25 dE) between ink sets (Fig 7).

A further, must important definition concernes ink strenght i.e. maximum possible ink concentration (or ink film thickness). Overinking (Fig.8) accentuates the dichroic behaviour in a way which makes color correction through masking impossible. Inking strenght (which might be given through Dmax) correspondent to points 6 in Fig.8 would be the highest possible for this set.

3. Colorimetric proposal

Due to the advent of portable spectrophotometers including both colorimeter and densitometer function (Celio, 1988) a redefinition of Preucil`s parameters might lead to a similar abridged characterisation for printing inks.

Fig.9 indicates such a procedure:

- Strenght is indicated by the maximum spectral density and is the only absolute value
- All relative values are referenced to an ideal ink F_o having "digital" behaviour between levels A and B. Transition situates at roughly at the indicated wavelenghts l.
- Setting level B=0 references actual ink F_1 to the best ideal ink F_∞ (Schrödinger`s color) concerning grayness
- Negative values of "desaturation" might occur (i.e. F_1 more saturated than F_o).

Examples related to inks of Fig.2,3,4 are given in Fig.10.

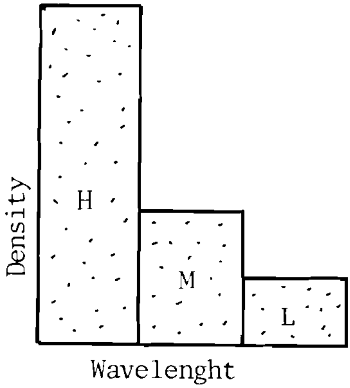
4. Conclusions

A formula for the colorimetric evaluation of inks quality has been proposed, which could be easily implemented in to-day`s spectrophotometers. We hope that it might help in particular cases. But generally speaking we do not believe that a complicated colorimetric process as printing can be exaustively described with a 3 or 4 dimensional vector.

Literature cited

Preucil 1957 "Highlights of the LTF survey of process color inks". TAGA Proc. 1957

Celio 1988 "Spectrophotometric instrumentation for graphic arts". TAGA Proc. 1988



$$H = \text{strenght}$$

$$g = \frac{L}{H} = \text{greyness}$$

$$h = \frac{M-L}{H-L} = \text{hue error}$$

$$e = 1 - \frac{M+L}{2H} = \text{efficiency}$$

and their inverses

$$M = (h - hg + g)\,H$$

$$L = g\,H$$

$$e = \frac{1-2g+h-hg}{2} = w\left(1 - \frac{h}{2}\right)$$

$$(w = 1-g = \text{"whiteness"})$$

Example : $H = 1{,}8$, $M = 0{,}72$, $L = 0{,}36$

$g = 0{,}2$, $h = 0{,}25$, $e = 0{,}7$

Fig. 1 LTF - Preucil relationsships

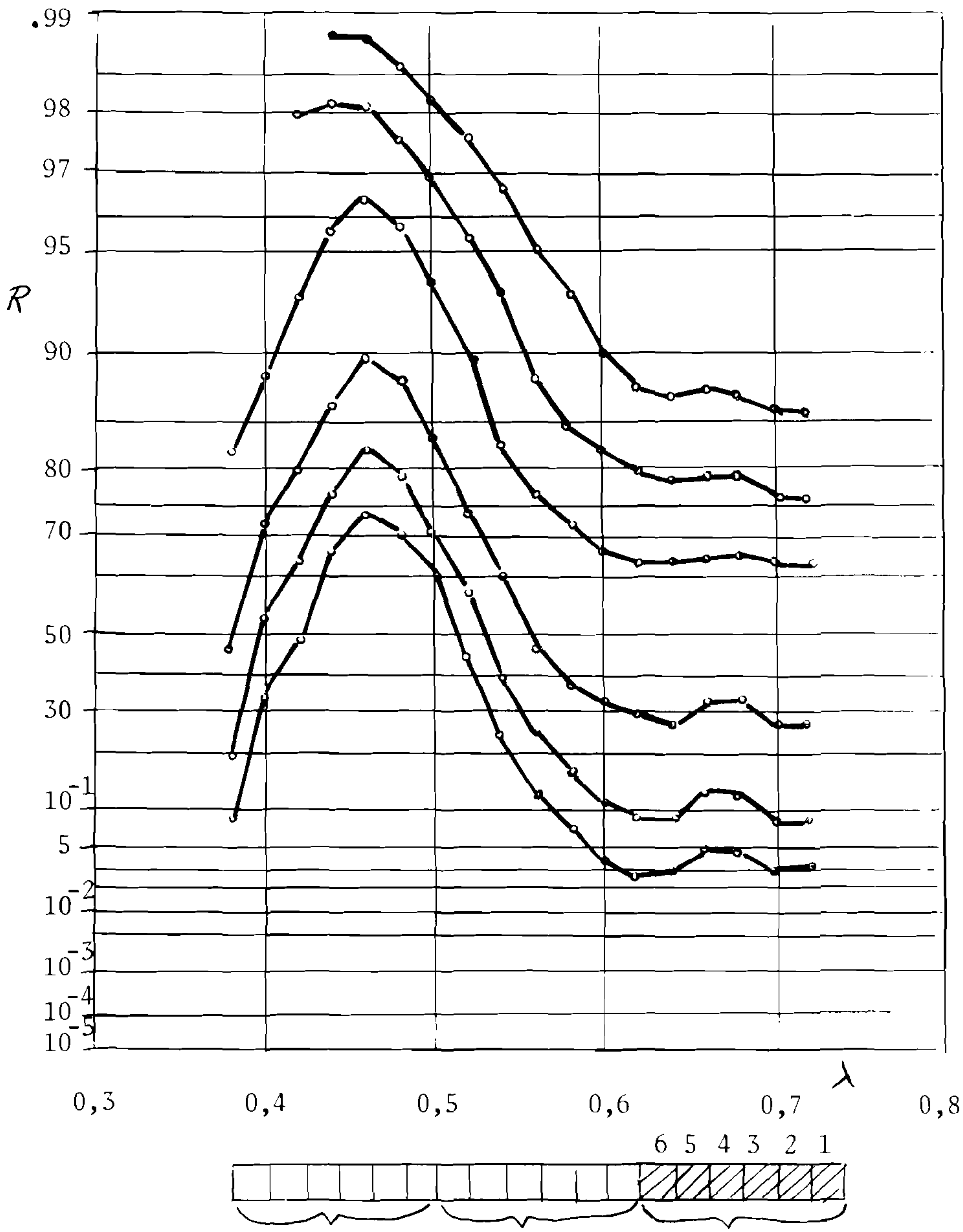


Fig. 2 Spectral curves of Cyan

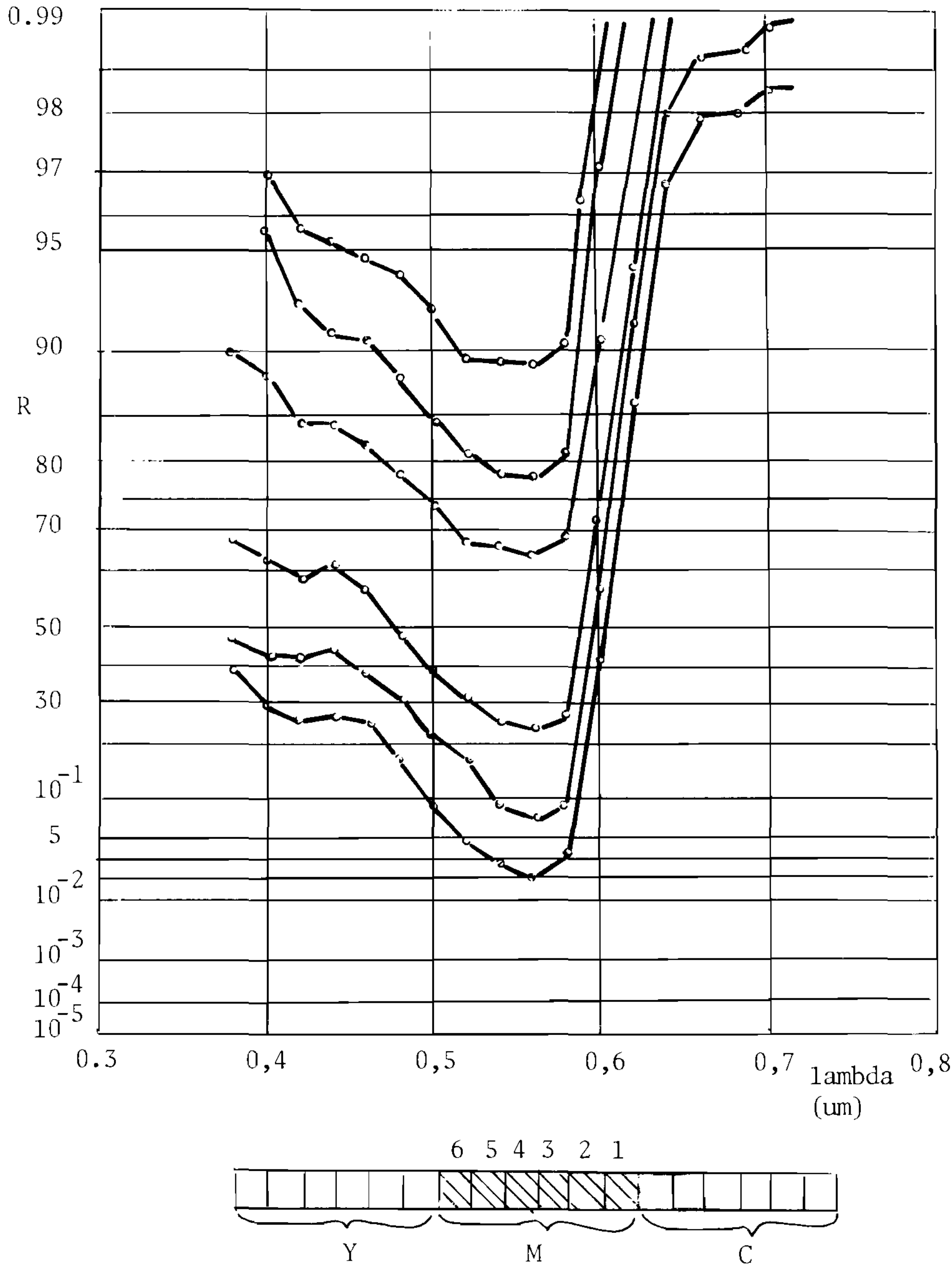


Fig. 3 Spectral curves of Magenta

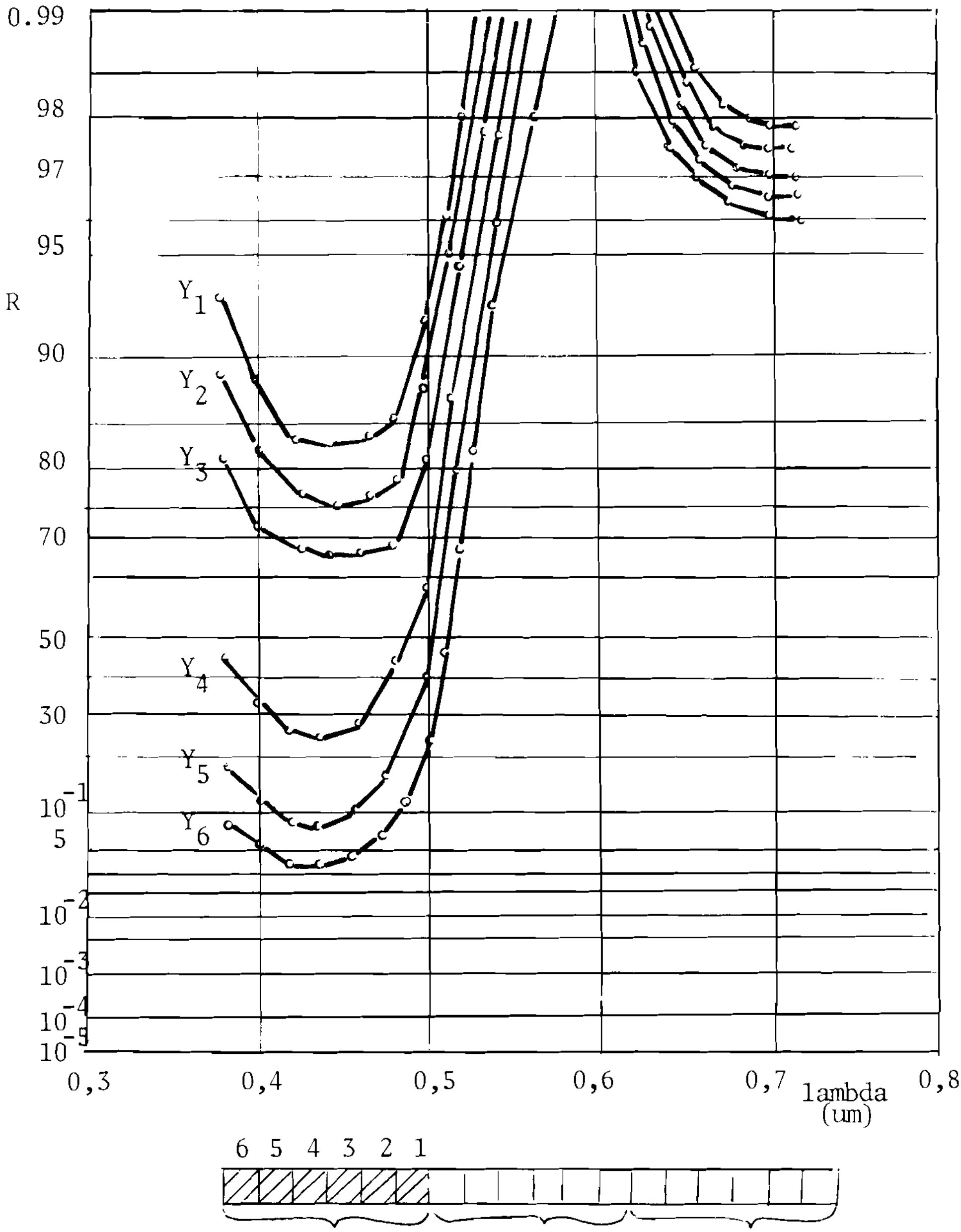


Fig. 4 Spectral curves of Yellow

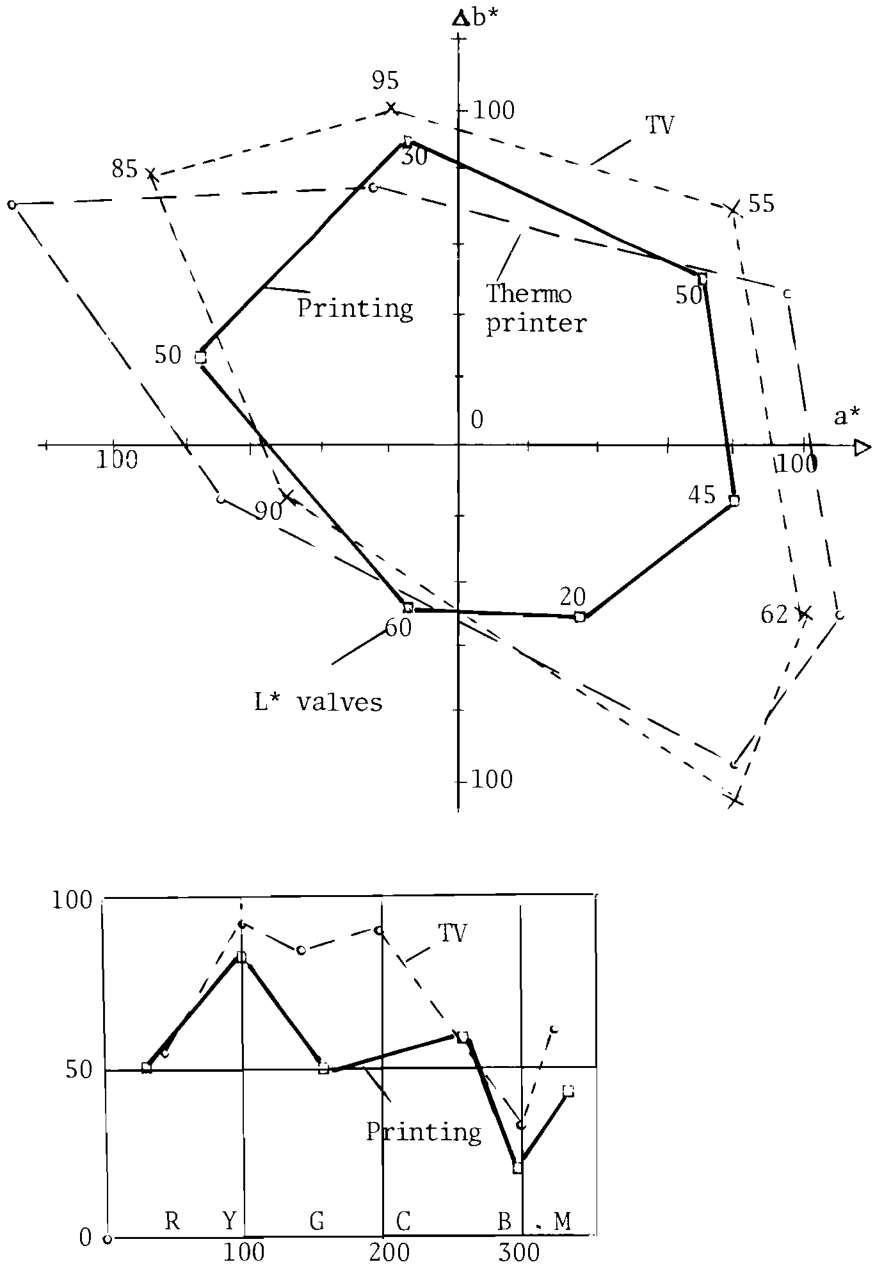


Fig. 5 CIELAB-Boundary of inks

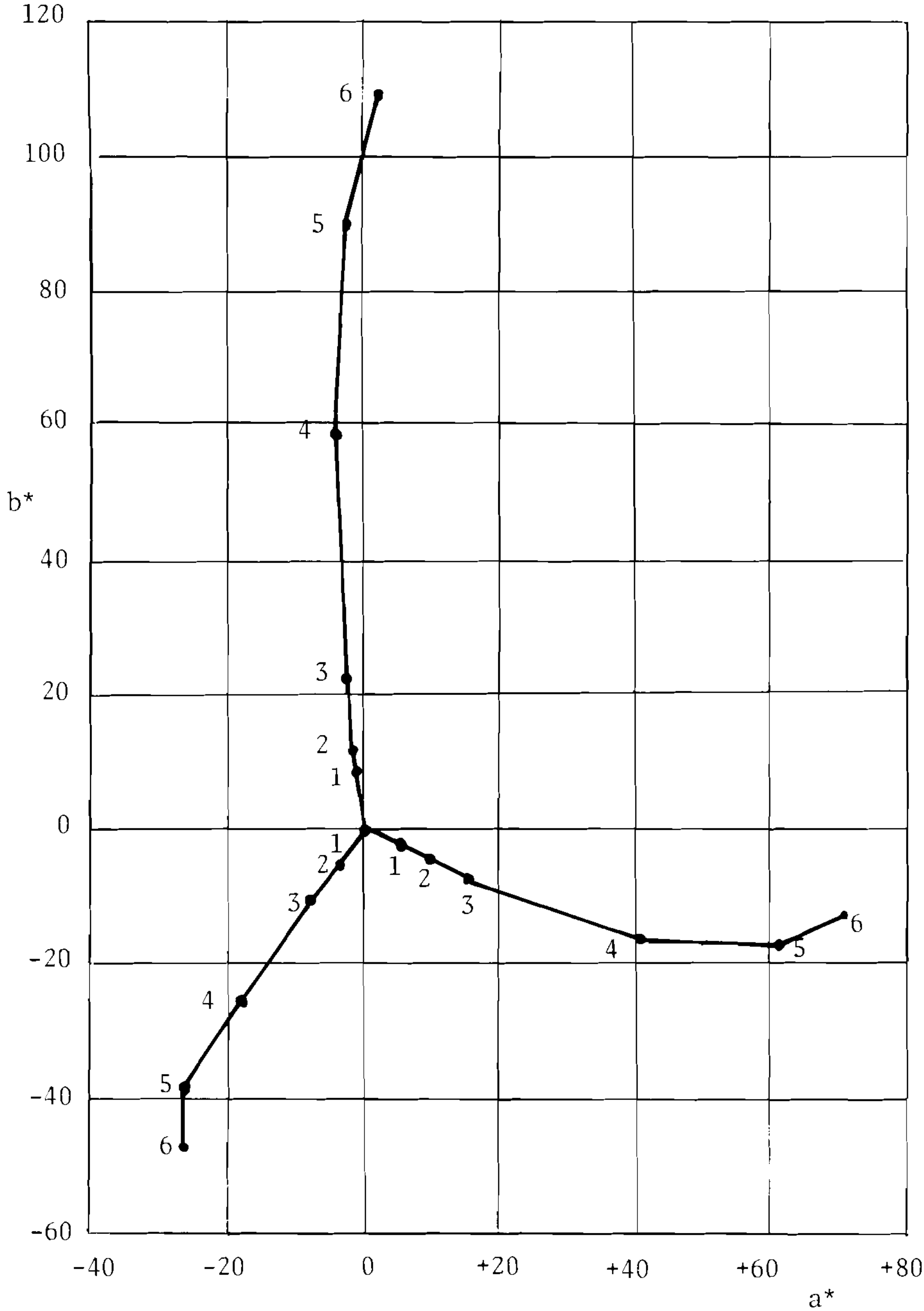


Fig. 6 Tonal characteristics of inks

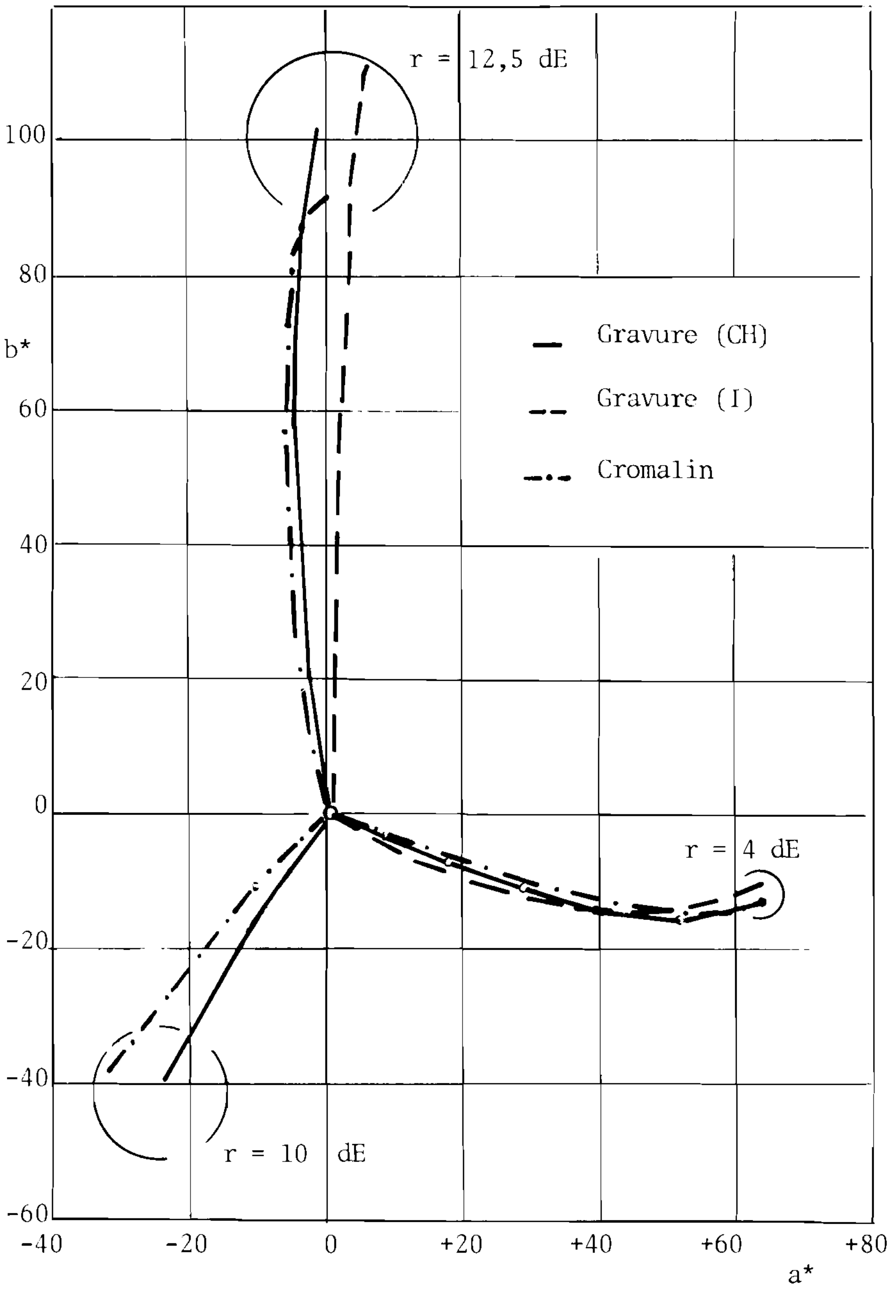


Fig 7 Comparaison of different sets of inks

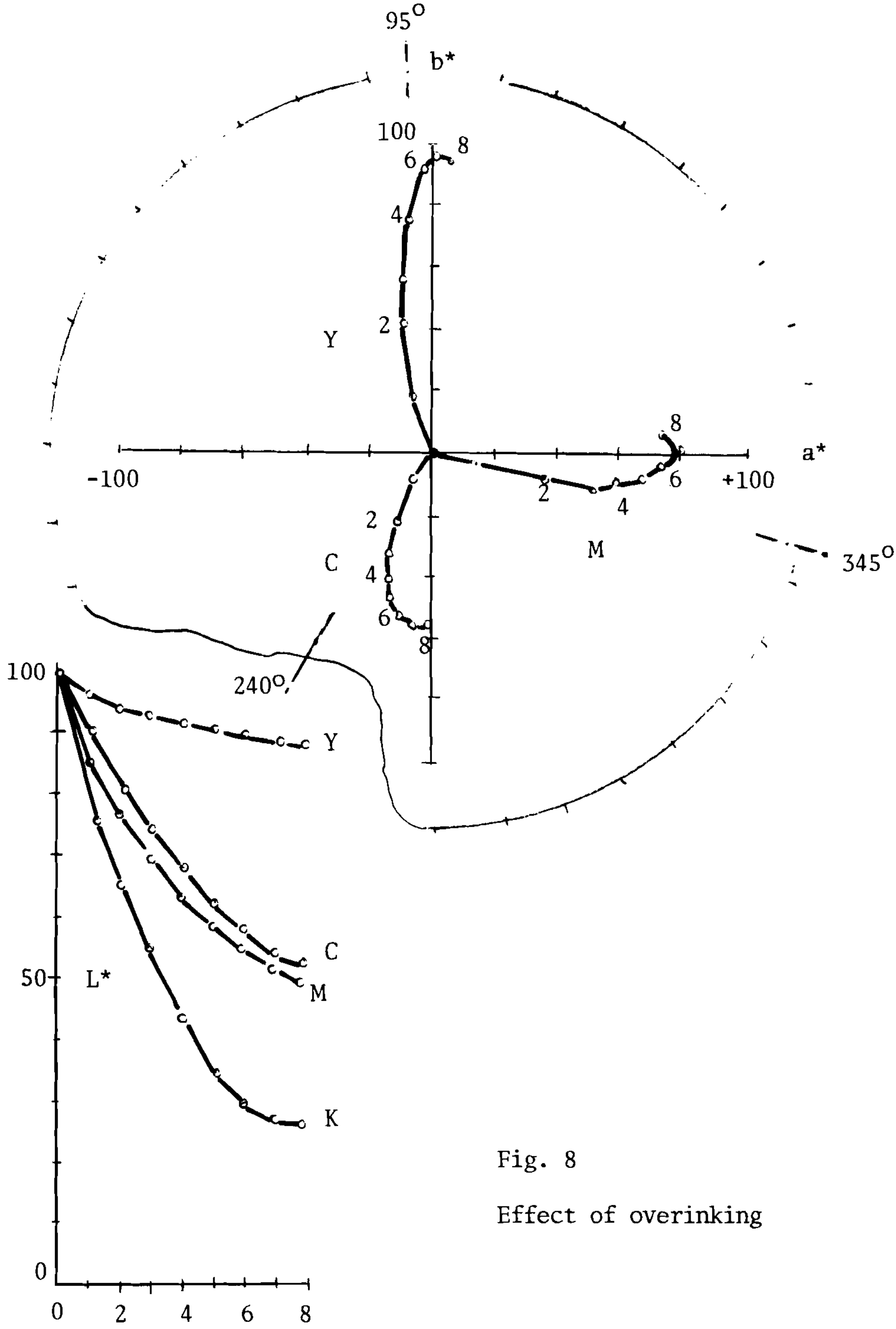
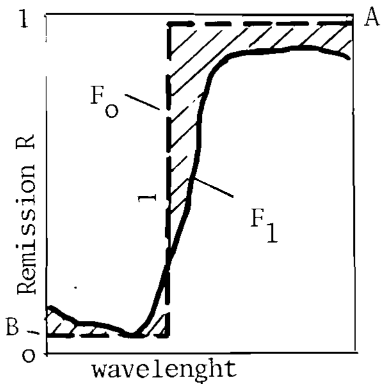


Fig. 8

Effect of overinking



F_o ideal ink (for a given D_{max})

$A = 1 \qquad B = 10^{-D_{max}}$

l = 530 for Y

l = 550 for C

l = 450 and 570 for M

F_1 actual ink

D_m	
	$L_o^* \; a_o^* \; b_o^*$
	$L_1^* \; a_1^* \; b_1^*$

$$C = (a^2 + b^2)^{1/2}$$

$$dH_{10} = (dE^2 - dL^2 - dC)^{1/2}$$

Strenght = D_{max}

grayness = $\dfrac{L_o^* - L_1^*}{L_o^*}$

hue shift = $\dfrac{dH_{10}^*}{C_o^*}$

desaturation = $\dfrac{C_o^* - C_1^*}{C_o^*}$

efficiency = $1 - \dfrac{\int (R_o - R)}{\int R_o}$

Fig. 9 "Colorimetric" specifications

	Inking	C_b	M_b	Y_b
D_{max}		1.44	1.66	1.46
Preucil	Strenght			
	grayness	0,12	0,01	0,01
	hue error	0,56	0,77	0,01
	efficiency	0,64	0,83	0,99
Colorimetric	strenght			
	grayness	0,18	0,15	0,04
	hue shift	0,0	0,0	0,0
	desaturation	0,15	0,10	0,05
	efficiency	0,48	0,72	0,95

Fig. 10 Examples