THE UGRA/FOGRA DIGITAL CONTROL WEDGE AND ITS APPLICATION

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Abstract

A new test wedge has been developed in order to control the rendering of digitally generated text and binary-coded images. The new control wedge is a software product stored on a floppy disk. The actual version is written in "PostScript", but other languages are possible. The new control wedge is based on a totally new idea: The line width and halftone dots of the element are not programmed within fixed dimensions; they represent multiples of the dot size of the output system being tested. This allows to test each output unit acording to its recording density. If the control wedge was defined in terms of a fixed line width and dot size, the chosen dimensions would either be far too coarse for high resolution systems or far too fine for low resolution systems. In the present version, 300 dpi printers and 3000 dpi laser image setters can be tested with the same element in order to obtain equally accurate results.

Introduction

The new control wedge includes elements, already present in conventional test wedges, i.e. vertical and horizontal line elements, dots in positive and negative polarity, resolution elements and halftone patches.
The new control element allows further to interrogate certain system parameters. As main parameter, the recording density is determined in dpi and the dot size is calculated therefrom in microns. Moreover, the necessary RIP-time is calculated and printed in msec.
The digital control element is illustrated in figure 1 (see last page) as output generated with three different recording densities. It is evident that, depending on the recording density, the line width, line distance and screen ruling are different.
For the screen ruling and halftone dot shape no particular values have been specified, but, the default values defined in the system are interrogated. If, for example, a digital printer is not programmed to print conventional halftone dots, the control element will render the continuous tones exactly as defined by the output system itself.
It has been taken into account that the binary output process may create phenomena which are of particular importance for evaluation. Above all, the stair effect appearing with diagonal but not with horizontal or vertical lines is adressed. To assess this effect, a star target has been designed. This element also helps to determine how far the resolution depends on the recording density only or additionally on the image formation process. For instance, if the particle size of the toner is larger than the recording density, the covered area, starting from the center of the star target, will increase.
Within the scope of a UGRA project, the various application possibilities of the new control

wedge will be thoroughly examined.
In order to implement this element into practice, a cooperation between UGRA and FOGRA has been agreed upon.

Description of the test elements

Text (figure 2a)

The word "Hamburgefons" in 6 points palatino is used to test type quality. The test characters are positive and negative what allows a sensitive assessment.

Star target (figure 2b)

The star target has been designed to determine how far the resolution depends on the recording density only or additionally on the image formation process. For instance, if the particle size of the toner is larger than the recording density, the covered area, starting from the center of the star target, will increase.

Checkerboard field (figure 2f)

Figure 3 represents three types of checker board fields together with a solid area, each recorded with three different dot sizes. In this schematic presentation the shape of the dots is round which is approximately true for most practical cases. As can be seen from the figure 3, no solid area can be obtained with small dots. Only larger dots which overlap their four neighbour dots produce a solid-tone. This is true for both the medium and the large dot size. However, if the dots do overlap too much, also the 50% step tends to be solid. This effect can visually be perceived as deviation of the tone value from to the theoretical value which is 50%. This effect is mostly marked in the 1x1-checkerboard field which is rendered solid. In practical situations this effect affects the transfer characteristic from film to plate. Equally, in case of text rendering it can occur that the quality of small letters does not meet the requirements for reproduction. Provided that the solid density is high enough (min. 2.5) the following rule applies:

The more the tone values in the three checker board fields (1x1, 2x2 and 4x4) are similar, the better is the technical quality of the reproduction.

This rule is of practical significance, as the identity of the checkerboard patches can be visually assessed, even in cases where an optical measurement fails due to the lack of contrast.

In a simplification the following statement can be made:
If the checkerboard rule is fulfilled, the recording process is unobjectionable. In case that the hardcopy output still shows deficiencies, they are due to material properties or errors in the stored digital image.

Moreover, there are some other test elements for diagnostic purposes. The line targets are used in the case, if the checkerboard test is negative and the reason is not evident. Generally, there is a large number of factors influencing the material output. They can be classified in the following way:

a) Electronical component
   - modulation of the recording beam

b) Recording beam
   - intensity
   - profile

c) Optical components
   - polygone mirror

d) Imaging process
   - imaging material
   - processing conditions
   - paper

e) Mechanical components
   - feed
   - vibrations

All these factors can interact what makes it more difficult to monitor the cause of quality defects. However, the individual elements are designed in such a way that they act in a specific manner in order to allow a systematic analysis.

Line elements (figure 2c)

If the ratio of the linewidth and line distance is equal, the theoretical dot area is 50%. Deviations from 50% indicate that the dots are printed too bold (>50%) or too sharp (<50%). With these test patterns the reason can be found, for example, why a checker- board pattern is rendered solid. In case that the corresponding horizontal and vertical line patterns are rendered solid, the resolving power of the material is too low or the recording beam is not adjusted to the line width. In case that only the lines in one direction are rendered solid, an elliptical shape of the beam can be the reason.

Small dot patches (figure 2d)

The small dots show the transfer characteristic of isolated dots in the highlights and shadows. To determine the resolving power, it has to be assessed whether they are present as positive dots and visible as negative dots.

Halftone wedge (figure 2e)

The purpose of the halftone wedge is to evaluate tone reproduction. For a routine control, however, the checkerboard patterns are a more suitable tool than halftone dots. The steps of the halftone wedge are sufficient to record a characteristic curve of the imaging process.

Specifications

Programming language: PostScript
Document type: avaiable as PS and EPS-file
Operating system: MS-DOS, Mac, Unix

Size

Length: 161 mm (191 mm including colour part)
Width: 17 mm

System parameters to be interrogated

Recording density in dpi

Halftone dot size in microns (calculated)

25,400 microns
dpi

User Name

To be chosen by the user.

Elements (defined as multiples of the minimal recording dot size)

Star target 0° to 90°

Division into one degree intervals
Line width: 2 dots

Type matter

"Hamburgefons" palatino 6 points
Polarity: positive and negative

Line Series

Ratio line width/distance 1:1
horizontal and vertical lines in widths of 1, 2, 3, and 4dots

Ratio line width/distance n: 24
horizontal and vertical lines positive and negative in widths of
n = 1, 2, 3, and 4 dots

Halftone dots

Screen angle: 45°

Distance: 16 dots
polarity: negative and positive

Arrangement: 1 = one dot
2 = two dots in diagonal position
3 = three dots
4 = four dots square

Halftone wedge

Dot area in %: 0, 3, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 97, 100

Regarding dot shape and screen ruling, the default values defined in the system are used.

Screen angle: 45°

Checkerboard field

Dot area: 50%

side length: 1 x 1
2 x 2
4 x 4

Color elements

The color patches are defined by their dot area.

C 100	M 100	Y 100	M 100 Y 100	C 100 Y 100	C 100 M 100
C 80	M 80	Y 80	DIN No. 14	K80	C 72 M 56 Y 54
C40	M40	Y40	DIN No.13	K40	C 28 M 22 Y 20

DIN Test Colors according to DIN 616

Nr. 13 Skin tone
Nr. 14 Foliage green

Application

Figure 4 represents schematically the way from the original to the printed image in electronic publishing . Each of the boxes represents an information transfer steps. The flow chart includes three of the most important processes which have the raster image processor (RIP) as common starting-point. The most direct process is the non-impact printing technology. The two other processes are digital film exposure and computer-to-plate technology.

Figure 5 represents the same flow chart and shows where the Digital Control Wedge can be applied. This one exists as pure PostScript file (PS) as well as an Encapsulated PostScript file (EPS) both giving an identical image. The PS version is directly sent from the computer to the output device which is equipped with a RIP.
The EPS version of the Wedge is imported into a layout software and permits to position the Wedge anywhere within the page. The final page is then processed in a color separation program and output as hardcopy together with the Control Wedges. The latter application corresponds to the use of conventional test elements.
The main application of the Digital Wedge in the graphic arts industry will be process control and diagnostic tests. The results of some tests are presented in the following.

The UGRA/FOGRA Digital Control Wedge 1990 was exposed under various conditions on film at a recording density from 1000 dpi to 1625 dpi. The results are listed in table 1. The numbers shown in table 1 represent the three steps with the dot arrangement of 1x1, 2x2, 4x4, assessed visually. Moreover, the percent dot area of the checker- board field and of the 50% halftone area was measured.

It can be seen that the dot areas of the checkerboard fields have an unexceptionable high deviation from the nominal values of 50%, predominately in positive direction. On the other hand, the corresponding percent dot area of the halftone patch deviates only slightly from 50%. In all cases with a too high dot area in the checkerboard fields, the corresponding dot area of the 50% fields is also increased.

In figure 6 the dot areas of the 50% halftone patch are plotted against the percent dot area of the corresponding 1x1 checkerboard field. The relationship between the two series of values is approximately linear. This relation illustrates the nature of the checkerboard field as a test element with signal character. The average amplification factor is about 5.

Both the recording density and the dot shape structure are the main factors influencing the image quality. This can be analyzed with the Control Wedge. Figure 7 illustrates photographic enlargements of the checker board fields produced with different recording technologies. The figure at the top represents a computer simulation. The dot shape was chosen to be round with a dot diameter giving a partial overlapping. Compared with this is the output of an 180 dpi inkjet printer. In the 1x1 field most of the dots are isolated and can be identifed as round. The same structure is present in the 2x2 and 4x4 fields.
The figure below originates from a 635 dpi laser imagesetter on film. The dot structure in the 1x1 field is not resolved. The 2x2 fields show a regular dot structure. Compared with the two foregoing cases, no substructure caused by individuals dots is evident. This proves that the laserbeam is producing a continuous line rather than dots.
The figure at bottom comes from a 300 dpi laserprinter. In this case the edge characteristic of the dots is influenced by toner particles which have an average diameter of about 15 µm.

Conclusions

The present study shows that the UGRA/FOGRA Digital Control Wedge 1990 is an indispensable tool for the process control in digital image recording. Its prominent features are the overall applicability regardless of the resolution of the recording process. Hitherto the following processes have been found as excellent application areas: digital film exposure, laser printers, ink jet printer, thermal transfer printer, computer-to-plate technolgy. Increased efforts will be made in future to get more insight into the nature of digital printing processes.

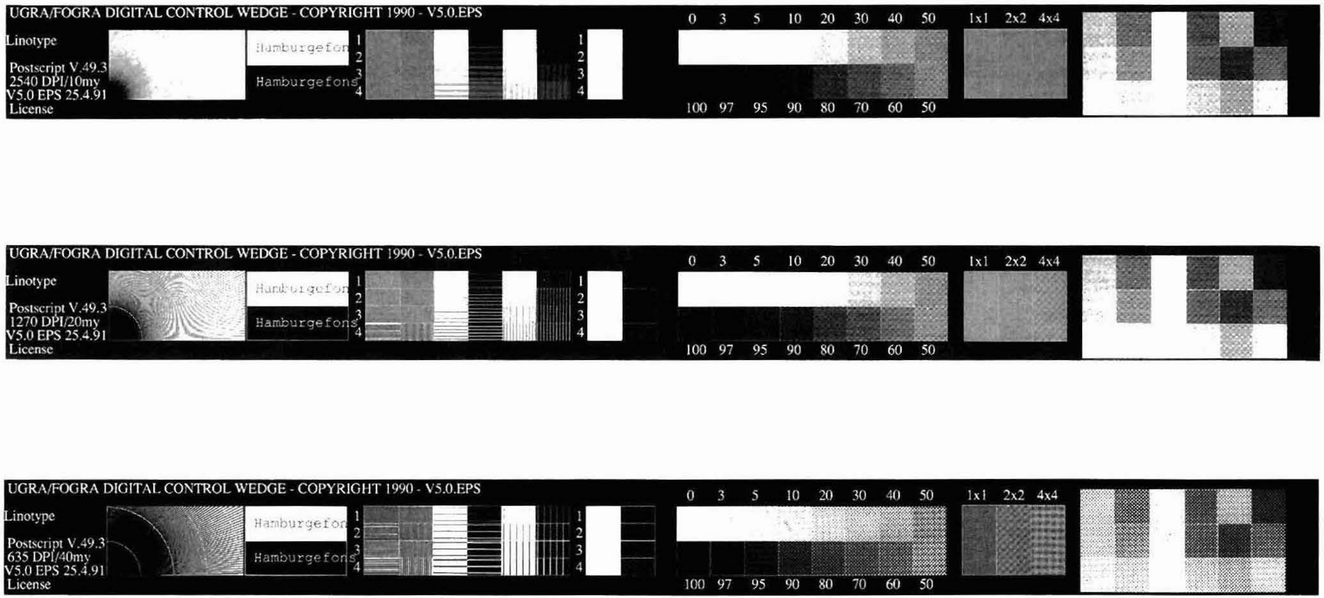


Figure 1 **Digital Control Wedge as output of a laser imagesetter with three different resolutions 2540 dpi, 1270 dpi and 635 dpi.**

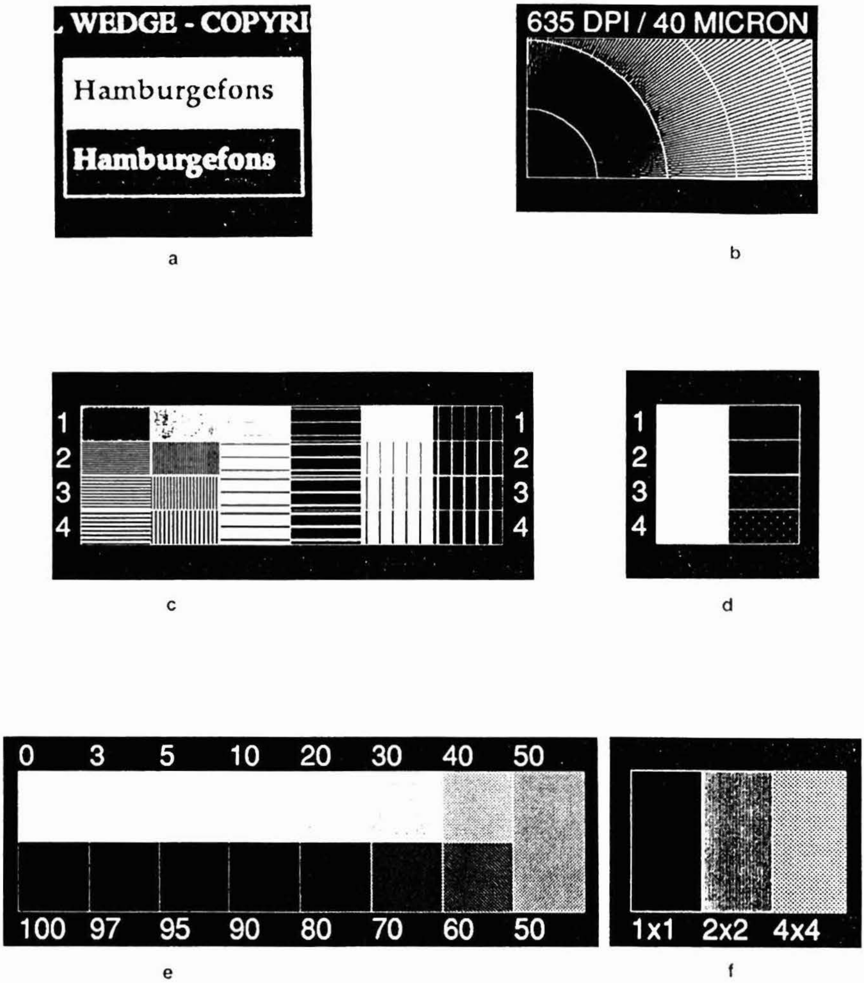


Figure 2 Monochrome elements in the UGRA/FOGRA Digital Control Wedge 1990

a: Text b: Star target
c: Lines d: Dots
e: Halftone wedge f: Checker board fields

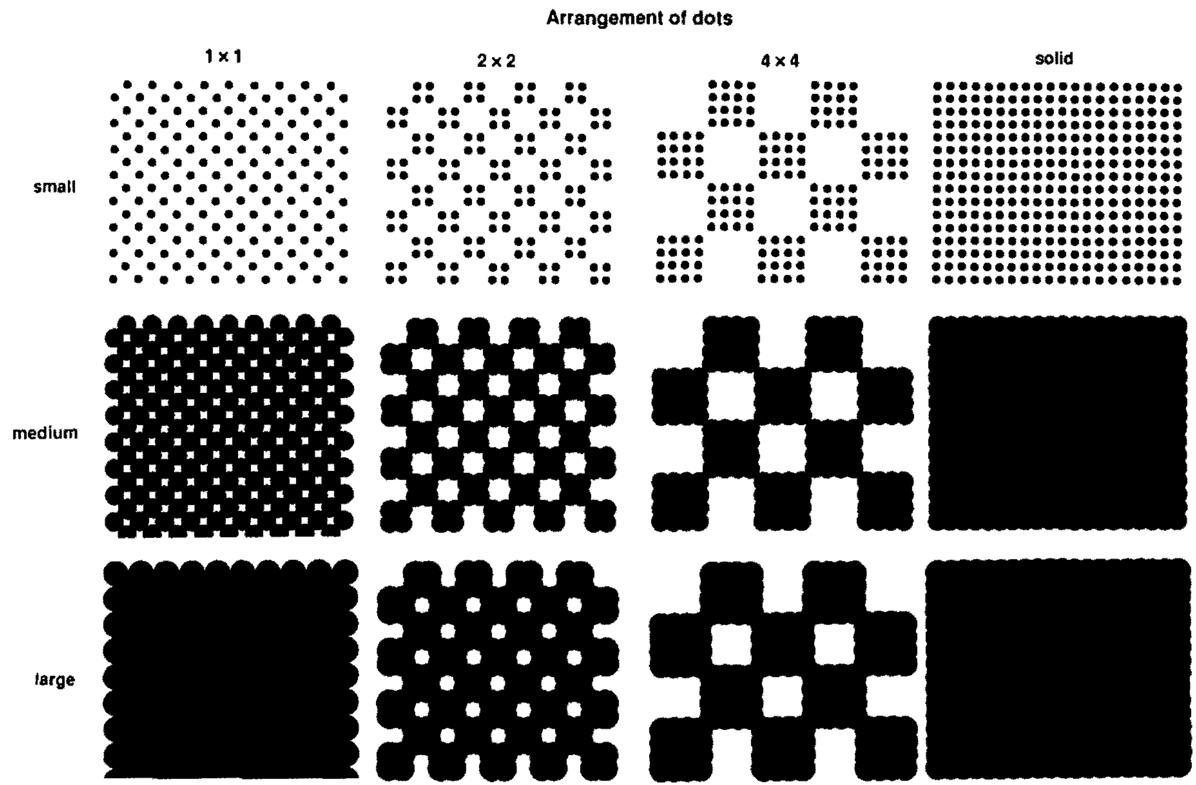


Figure 3 Influence of dot size on the % area in a 50% checker board field and in a solid-tone field (computer simulation)

Fig. 4 **Production chain**

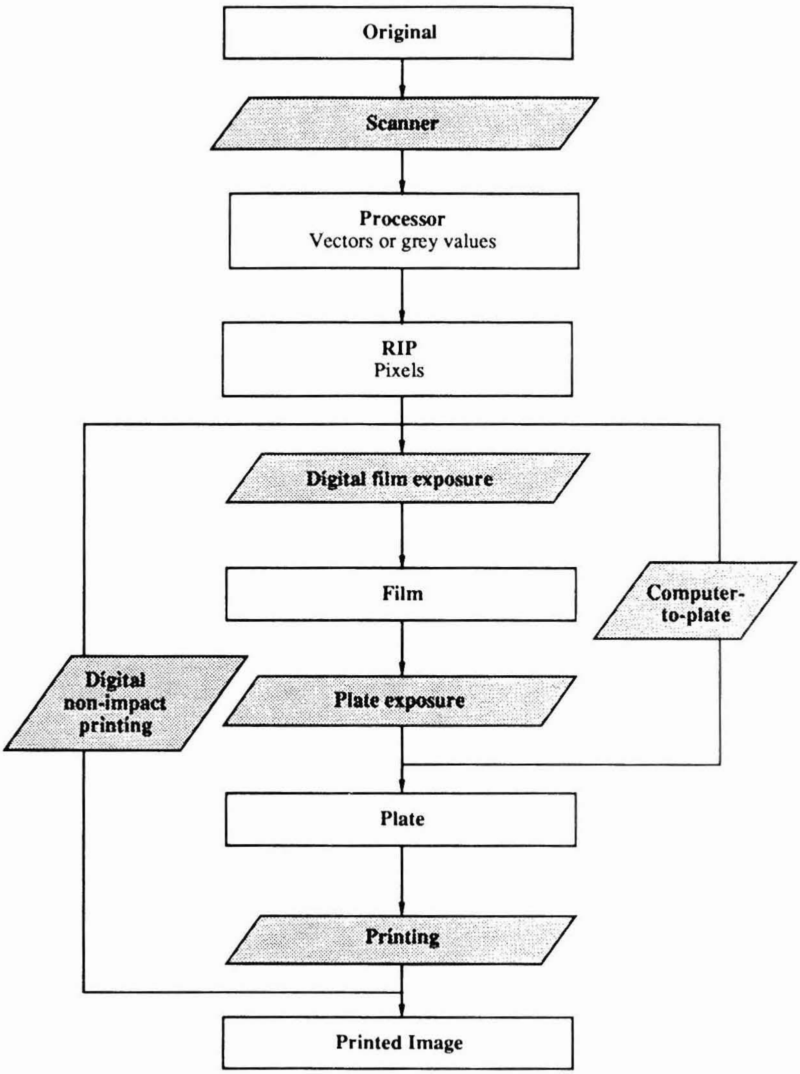


Fig. 5

Production chain

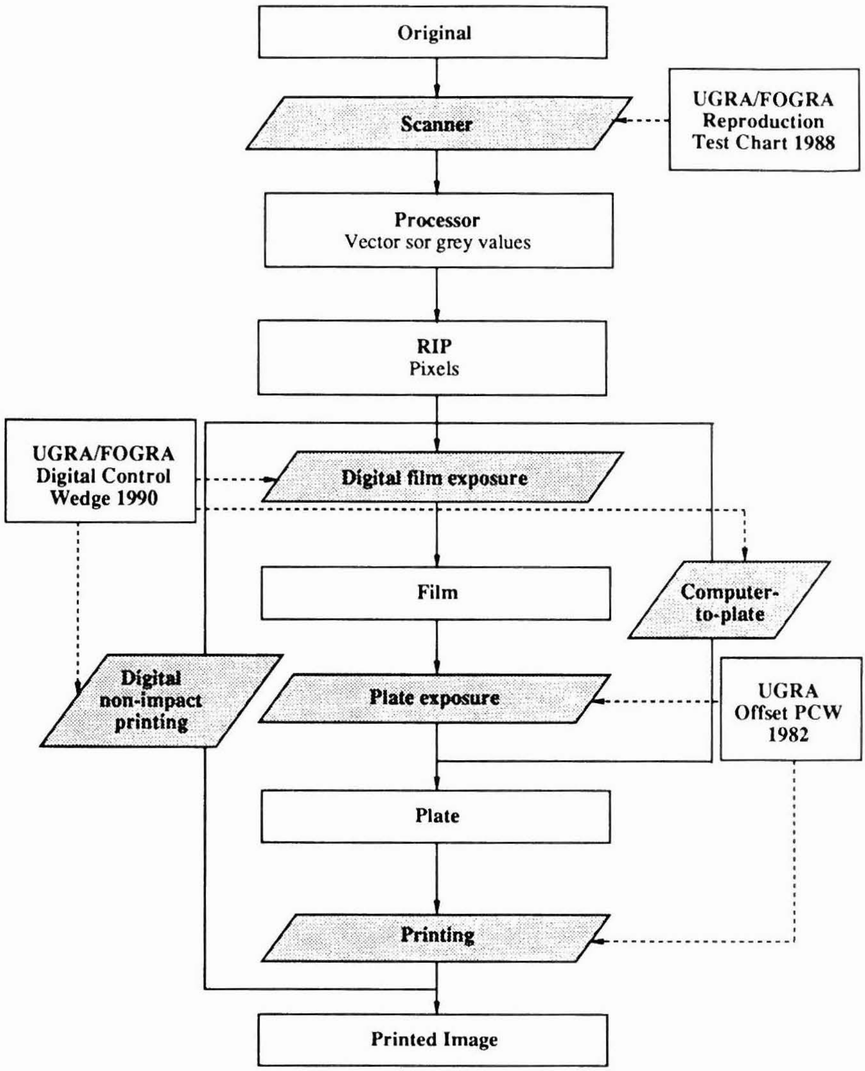
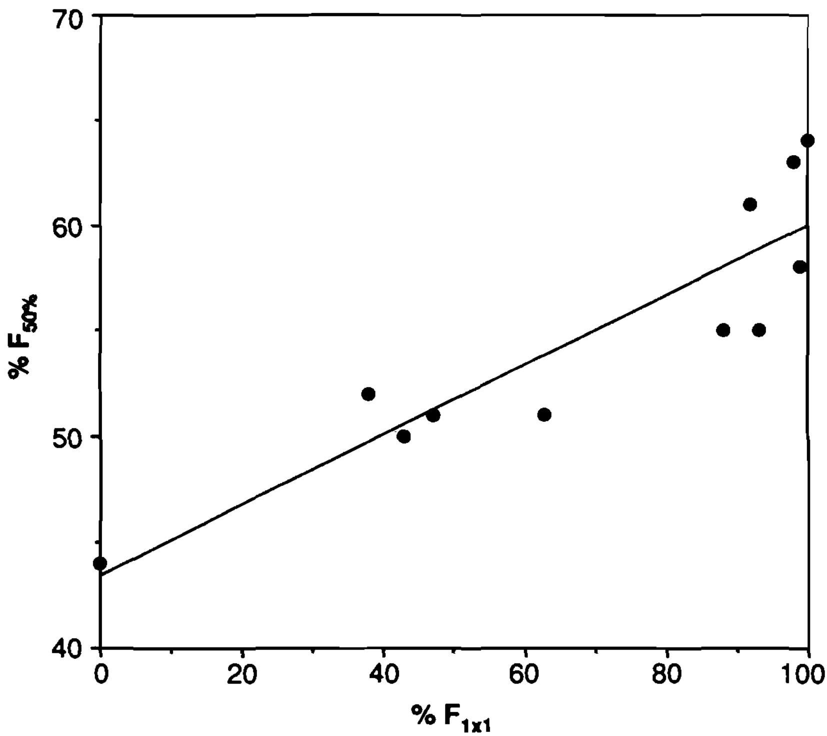


Fig. 6

% Dot area in the halftone field
vs
% dot area in the checkerboard field



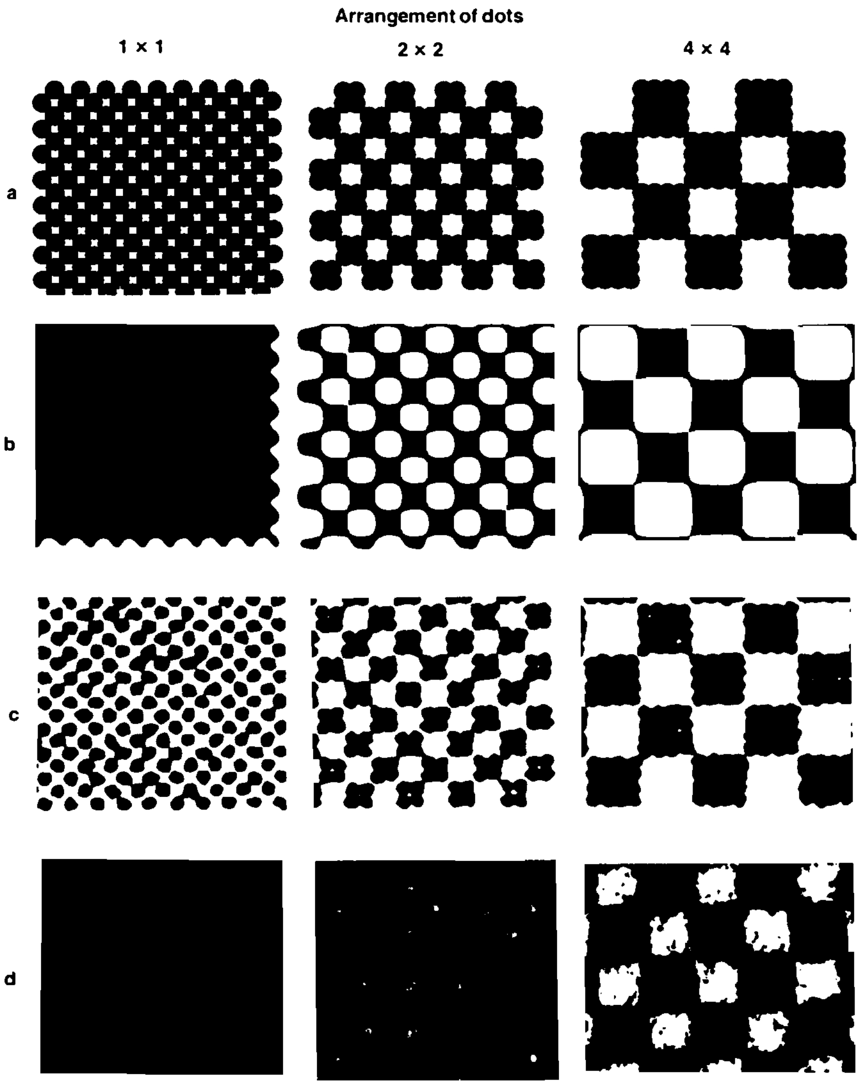


Figure 7 Influence of recording technique on dot shape rendering

a Computer simulation
b 635 dpi laser exposure on film
c 159 dpi inkjet
d 300 dpi laserprinter

Table 1: Evaluation of film exposure

Sample	dpi	Positive elements printing (step No)			Line pairs resolved (step No)		Negative elements visible (step No)			Solid density	Dot area step 1x1	Dot area 50% halftone
		hor. lines	vert. lines	dots	hor. lines	ver. lines	hor. lines	vert. lines	dots			
1	1016	1	1	3	1	1	1	1	2	5.14	38	52
2	1016	1	1	2	1	1	1	1	2	5.14	88	55
3	1016	1	1	2	1	1	1	1	3	5.14	99	58
4	1270	1	1	1	1	1	1	1	1	3.03	47	51
5	1270	1	2	2	1	2	1	1	1	4.94	0	44
6	1270	1	1	1	1	1	1	1	1	3.67	43	50
7	1270	1	1	1	1	1	1	1	1	2.91	63	51
8	1270	1	1	1	1	1	1	1	1	2.79	92	61
9	1270	1	1	1	2	2	3	3	>4	5.30	100	88
10	1003	1	1	2	1	1	1	1	3	5.08	93	55
11	1625	1	1	1	2	1	2	1	3	4.80	100	64
12	1200	1	1	1	1	1	1	1	2	3.40	98	63