OBJECTIVE AND SUBJECTIVE QUALITY OF A SCREENED IMAGE, TODAY

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Abstract. The print, for reproducing the images, demands that they are divided in dot percentages, in proportion to the light and shade of the original image: that is to say they must be screened. In the screening, therefore, beside the image information (input) there must be also the repartition or fractionization information (screening necessary for the output). The quality rendition of a printed image is the sum of the two pieces of information: IMAGE + SCREEN. The computerized automation for the preparation of both halftone (screened positives or negatives) and the necessary data for producing the printing form, demands a considerable prefigurazion capacity of the final quality result, that is of the printed matter. Characteristic of the computerization is the automation of both the operative cycle and the control system. Information and decisions, must be declared at the moment of the SET-UP and therefore both of them at the input, and not as it was usually done, INFORMATION at the input and DECISIONS at the output. The prefiguration capacity can be acquired partly by EXPERIENCE and partly (larger part) by STUDYING. We shall present in this lecture a few ideas for a better rationalization of EXPERIENCE, having it derived from the critical capacity of control of the halftones, in anticipation of the printed quality rendition. We shall supply moreover a few ideas about how to develop by oneself or how to use, a "SOFTWARE", to enrich the capacity derived from STUDYING, to facilitate the preventive control operation at the moment of the SET-UP.

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INTRODUCTION

We call colour separation the photoelectronic or merely electronic process, suitable to separate the elementary components of a chromatic image. Every colour image, either natural (landscape, environment, figure, objects etc.) or reproduction of nature (painting, picture, drawing, print, etc.) can be seen by us because of its intrinsic selective capability, with respect to incident light radiation. Natural objects, as well as images, when striken by white light (polychromatic light), show their property to absorb some radiations which said light consists of, and to reflect or transmit others. Only what is transmitted or reflected strikes our eye, therefore only that portion of radiation will raise active stimuli which being transmitted by our eye to our brain, will permit us to embody, inside ourselves, the shape and colour of the object or image observed.

We know from physics, that the so called white light, is such because it consists ot three fundamental radiations: BLUE radiation, GREEN radiation, RED radiation. The separation technique exploits this phenomenon and separates the three radiations coming from natural objects or from their images. These three separated elements stand as the basis to rebuild an image called reproduction, either of the object or of another image that generated it. The image or prime object, is called "ORIGINAL COPY". It is also just called "original", but it isn't quite correct to define it as such. Philosophically the very original is the virtual image formed in the observer's brain when he observes a natural object or an image. The original therefore is more than a simple object, it is the object plus the idea, the interpretation, the comprehension, the psychological charge that the observer gives to it as additional value.

For this reason, the original copy is just one of the elements that make up a reproduction, the second element being the idea, expressed or dreamed as such, that one wants to associate with it. Only from the function of the two elements the "optimal" reproduction is generated, the one commonly accepted.

Color separation (analysis), is technically necessary in order to rebuild (synthesis) the image reproduced through such means and processes as to guarantee an acceptable rendering. There are two processes to accomplish this function: the televisual optic-electronic one based on the additive synthesis and the photographic optical-photo-chemical one based on the subtractive synthesis. The printing process exploits both these principles and builds up its own, similar to television in the analysis and similar to colour picture in the synthesis.

The image to be reproduced is scanned, by dots and subsequent lines (scanning). Each separated signal is transformed into an impulse of analogic electric power (digital in future). An additional explanatory information is applied to such power, so as to guarantee a tonal and chromatic quality rendering completely similar to the original (starting) copy, though rebuilt with completely different raw materials. The signal thus elaborated is utilized to expose a film where the tonal values are interpreted as percentages of printing and non printing areas and the colour remains separated into three monochromes plus one. The three monochromes refer to the subtractive primary ones: yellow, magenta and cyan. The "plus one" refers to black, an essential part in the printing processes for the complement or reinforcement of the depth or contrast element and fundamental to efficaciously guarantee the absorption-reflection effects with poor raw materials, such as printing inks and paper.

The need for black in the printing processes, determines the use of two techniques: the so called "trichromatic printing" and "quadrichromatic printing".

By "trichromatic printing" we mean a work of colour separation, where the reproduction as a whole is practically obtained by the three basic monochromes: yellow, magenta and cyan.

The black, intervenes only as a complement of the drawing in the deep dark-tones of the image and as a support to the cyan. By "quadrichromatic printing" instead, the black is devoted to the whole drawing of the image, excluding the first modellings, while the colour works exclusively in the chromatic areas with a drastic reduction (about 50% and more) in the non-chromatic areas.

The technical structure of the two separations is remarkably different; both of them are fit to solve advantageously various technical problems in the printing processes. The choice of one or of the other, appears to be more linked to the acceptability by the printer rather than to the real operative benefits that "four-color printing" can offer compared with "three-colour printing". This last remark, is quite true in Europe, while it is the opposite in the USA. However, it is necessary, for a reproduction engineer, to know and be able to manage both the techniques. Therefore in the quality control of halftones, we'll take them into consideration, in detail, separately.

SUBJECTIVE REQUISITES OF THE QUALITY CONTROL

The quality control we suggest, a system of superimposing the monochromes, being terminal to an intermediate process, is partly of objective nature (that can be measured), and partly of subjective nature (visual evaluation, statistic survey, experience). In this respect, we'll use three common terms, but with specific technical importance: DRAWING, VOLUME and ILLUMINATION, whose contents must be discussed as well as their meaning.

By DRAWING we mean the accurate and sufficient delineation of the contour of the objects making up the images as well as the texts. In a halftone suitable to obtain a printing form or in processed data to obtain a halftone or directly a form, or a print by ink jet systems, xerography, etc. The drawing must be emphasized if you want the final result to be compared with the original, in spite of the unavoidable deviations in procedures, to be imputed to the more or less marked diffusion of ink in the paper fibers.

An important evaluating parameter, in the drawing definition, is due to the "apparent contrast": the contrast of subjective influence, not the objective contrast, better known as gradient. We can call apparent contrast the property of an image to put more or less in evidence the tonal differences between the light tones (illuminating part of natural objects) and the dark tones (parts little lighted or not lighted of natural objects). This characteristic, in the present reproductive technique, is a choice to be made at the beginning of scanning, according to printing conditions. It represents the basis of the degree of pleasantness, therefore of acceptability of a reproduced image.

Strickly linked to drawing there are also two other definitions of considerable subjective importance: DETAIL and image DEFINITION. "Image definition" can also be called focus, sharpness, readability, clearness of contours; while "detail" concernes in a higher degree the separating step between a tonality and another, even if of a very small value. We can say that drawing is the general aspect of image reading, while definition and detail are the tiny elements, the fine particulars, whose absence leads to a very poor evaluation, due to lack of pleasantness, therefore to a scarce acceptability of an image.

The VOLUME of reproduction instead should express the body, the roundness the apparent three-dimensional aspect of the reproduced image. It's not only a matter of saturation. The reproduced image must but also completed by a rich or at least sufficient modelling, suitable to supply an aspect of completeness, as a simulation of the typical aspect of the natural object. The volume, we may say, is the ensemble of the drawing in all its darkclear aspects, with the chromatic saturation and plasticity peculiar to the reproduced subject. This is to make the reproduction similar to the original copy if well done; similar to the reproduced natural object, if the original copy is of poor quality or partially accepted.

The term ILLUMINATION is understood as having a meaning similar, but quite richer than the common definition. We say in advance that illumination in a chromatic reproduction, is always obtained with the control of yellow saturation. In this there is a certain similarity with the definition of the common term, lighting of natural or artificial type, that is to say with warm effect, therefore with prevailing yellow; but the meaning we want to give it, is still stronger and more significant. For instance a green with little yellow is cold, as cyan is prevailing and is said to be little lighted. A glass containing orange juice or white wine if little saturated with yellow, is said to be lacking illumination. A deep shadow, made up of black, cyan and magenta if having a pretty amount of yellow will look a little less deep, more modelled, say slightly illuminated. Taken in this sense, illumination distinguishes itself neatly from the concept of clearness. An area is clear when it has low percentage content of hue. Clearness in print is obtained by leaving the paper support show through. Illumination instead, we repeat, is the amount, at any clear-dark value, of the prevailing saturation of yellow.

SCREENING OF HALFTONES FOR OFFSET AND GRAVURE

By the progressive standardization of processes, either offset or especially gravure etching, mechanic-electronic, therefore with the almost generalized adoption of semiautotypical process in favour of conventional continuous tone, the use of halftone screen in gravure is becoming normal, such as the one used in offset printing processes. A halftone screen, whose gradation is obtained by factorizing in percentage the printing-areas having a complete scale, i.e. 4-6% to 98-99% is becoming the almost unique way that characterizes the printed images in all printing processes. This process is not limited only to the achievement of a printing form, but it is also used as an interlocutory element for digitalization of the images, because of the very small occupation of disk memories (provided the same completeness is given), if compared to the memorization of the continuous tone.

The so called screened image, i.e. with tones broken up in dots having proportional percentage cannot certainly be defined poor with respect to the pictorial or photographic images so far considered to be of optimum quality. The rendering of an image, expressed in bit per square centimeters, can also be higher for a halftone compared with the other techniques available today. The process of transformation from original copy to halftone image in order to permit the repetitive reproduction by printing process, can guarantee a consistent increase in quality rendition and not a loss, as we have always thought or we still think of. It isn't easy to attain and keep the quality requisites demanded from a halftone such as to guarantee the same optimum quality rendition in the final printing result. This however is not to be considered impossible, on the contrary, by the means available today it's possible to guarantee it by a minimum of technical requisites and a maximum of technological applications. This last remark may look odd, but it will prove true as we go on, in this lecture. Today, the kind of means we employ doesn't matter so much, instead, the mental capacity and forecast ability are important related to what we want to achieve starting from certain technological principles.

Taking into consideration, for the moment, the making of a halftone, but thinking that tomorrow it will be exclusively represented by digital data, without changing the concept in its essential terms, it is interesting to realise in what the requisite differs from one printing process and another. The fundamental characteristic lies in how a halftone is used. In offset it is used to obtain a printing form (plate) for direct copying. In gravure it is used to obtain an opal-film, or to be read directly or again, as a halftone consisting of data, to interact as an input in the electronic gravure machine or exposure offset plate.

The offset halftone must contain, as second requisite, a well determined ratio in dot percentage of highlihgts, middletones and shadows, depending on the type of paper on which we'll print. This aspect in gravure process is less evident and almost consistent, at a rather low value. Different types of paper in offset remarkably influence the "degree of dot gain at the moment of printing", therefore reductions in percentage values on halftones are required. In the gravure process instead, Dot Gain is of a value between 4%-8%, compared with offset where it can vary from minimun 10%-12% to maximun 30%-35%.

An important element of the characteristic of the halftone for gravure, compared with the offset one, is the rendition of printing strength due to the concentration of gravure inks. The halftone percent range, for gravure, starts from 3% zero gravure value, the work beginning on 5% equal to about 25-30 microns diameter of engraved cells. From this percent, with computerized program control, we get to maximun 98% with a diameter of approx 180-190 microns. The printing rendition of such a gravure, results far better than the conventional type of cell: not only for the typical pyramidal configuration, regular and consistent, not affected by anomalies typical of chemical etching, but also for the characteristics that such a pyramidal geometry confers to the emptying of the cell, which emptying is also favoured by the pressure roller electrostatic action.

Owing to the typical reading-engraving mechanism to make gravure cylinders by electronic means, screen line of positives are optimal with 60 lines/cm. Higher screen lines, 70-80-90 lines/cm that, at first sight would seem more consistent, on the contrary are not so, and experience has proved this.

Experiment is therefore going on towards a remarkable standardization convergence in the characteristics required for halftone positives. From what has so far been tested 60 lines/cm result optimal screen lines both for offset and gravure with electronic cylinder engraving. 70 lines/cm are instead optimal for gravure cylinder preparation with chemical etching; with these screen ruling, optimization of "moirè" both for halftone and gravure screen is best achieved.

The difference between a halftone positive for offset and a halftone positive for gravure depends only on the printing condintions: middle tones in relation to dot gain; light tones still according to dot gain, for offset and in relation to tonal decrease, due to engraving, for gravure: shadows in relation to tonal decrease, due to inks, for offset and to the considerable increase, still due to inks, for gravure.

Moreover there is a remarkable mental difference between the fulfilment of gravure orders and the offset ones. This last fact is the one that creates the biggest difficulty in the unification of the two processes. We are sure however, that the refinement of standards and the increasing experience, will help us to reach substantial unifying targets between the two processes. For this purpose, an efficient and rational training of the operators in charge of preparation will be very useful. Up to now the study of transport and print parameters has been quite neglected; such parameters, however, must be supplied always up to date to the operators that work in halftone preparation. We hope for the future that not only the dynamics of reorganization of operative cycles may be continously improved and studied, but also a step may be made towards a rational and cultural exploitation of this profession with less training and more education.

All this leads us to understand that we have already entered the time when work is considered as study and not as fulfilment achieved by approximation in the dynamics attempt-mistake-correction.

COMPUTERIZATION FOR OTPTIMIZATION

The future technique will tend to optimization. The progress of new technologies, sophisticated automation and computerization, will lead engineers to concentrate almost exclusively on decisional logics. In fact a characteristic of this way to manage the work is that of deciding the operative cycle and declare at the set-up, the control parameters that the computerized system will make.

This capability of formulating in advance the decisional criteria requires the learning of mental techniques of prefigurating the final result. The professional education of engineers, therefore, shall have to change. More than aiming at the acquisition of exclusively manual techniques directed to build up experience, study is necessary aiming at solving technical problems and a lot of simulation in order to become skilled in the use of specific algorithms; learning and managing the parameters in order to obtain prefixed results; intervening on parameters to affect the results; learning and refining the techniques for the analysis of results, with a view to acquire standard data but especially to learn how to manage the quality control, in its subjective aspects (that can be measured) and in its objective aspects (psychological evolution, statistical survey, study of the idea and listeng to customer's requests).

In order to quicken the acquisition of work prefigurative capability such as required by systems based on data processing, therefore exempt from the possibility of controlling intermediate products, it is useful to have ourselves assisted in the set up by a computer: computer assistance by technique of CAW type (Computer Aided Work) as well as by CAI techniques (Computer Aided Instruction).

The basis of the problem lies in the difficulty to understand how optimization can be reached in image reproduction, in accordance to customer's expectation and printing conditions at the same time. And inside this problem, there is another difficulty: the correction of objective and processable data with subjective concepts hard to be put into data or difficult to correct and with interaction influence still little known, therefore difficult to manage.

A tentative proposal in this sense is presented in the second appendix. We intended to supply a simple help, but of marked technological content, such as it can be obtained today through a minimum HARD and concentrating particularly on SOFT. The basic idea of this work rose from educational and didactic demands also usable in the technique field, and considering the remarkable demand of stage education, made by the companies, in time and quantity not allowed by old teaching methods.

CONCLUSION

Among the various means of transmission of visual information, Press holds a considerable position. New technologies are contributing indeed to improving the quality of this means which, though using poor raw materials such as paper and ink, is able at present to guarantee a competitive quality rendition.

The quality standard is guaranteed mostly by electronic applications: image scanning, transformation of the image signal from analogic to digital, automatic make-up, electronic screening, direct action onto data for chromatic corrections. To manage adeguately these requisites, study is more useful than working experience. The advantages could be summarized as follows:

1. In procedure passages, as well as in the acquisition of data for image reproduction, screening permits to avoid loss of quality and even guarantees a consistent increase in some cases.
2. Compared with past time, present screening techniques, in reproduction of images for printing, also include retouches or improvements; this is in fact unavoidable if we adopt the mere photographic process.
3. Studying attentively the relation between quality rendition and printing conditions, it is possible to transform, for the different images to be reproduced, the average value in optimal dot percent $\geqslant$65% $<$80% depending on the different printing processes, in order to guarantee more definition and detail, compared with the original image.
4. By the method of superimposition of positive halftone monochromes, it is possible to acquire critical skill to judge the quality of the semi-finished work, so as to foretell the final result with good guarantee.

5. By a suitable mathematical model operated by a computer, even of limited capacity, it is possible for us to be assisted in the setup operations, to tell in advance the image rendition in dot percent, to verify inductively the chromatic composition, to simulate results with changed printing conditions.

Which are the disadvantages of all this?
The lack of the operators' training.

Today it's important to cope with the gap: technological progress and timely training of all people concerned with directive as well as operative tasks.

Today's electronic-data processing revolution, is not so much concerned with the machines rather than with mental aptitude. Culture must overcome operative skill.

What yesterday was intuition or skill accumulated by experience, today must be expressed in parameters, as processable as possible.

It is still difficult to dominate the optimal quality rendition due to objective facts interacting with subjective conditions but, by the present means, a rational approach that depends only on our cleverness is possible.

APPENDIX N°1

CONTROL METHOD*
OF OFFSET HALFTONE POSITIVES AND GRAVURE CONVERSION
IN VIEW OF THE QUALITY RESULT
PRINTED WITH EUROPEAN SCALE INK

OPERATIVE SISTEM**:
SUPERIMPOSITION OF HALFTONE MONOCHROMES

TRICHROMIC SEPARATION

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*METHOD Procedure suitable to guarantee, on the theoretical-pratical plane, the functional character and faithfulness of a work or a behaviour.

**SYSTEM Linking up of elements into an organic whole.

BLACK MONOCHROME OF TRICHROMATIC SEPARATION (DEPTH)

GENERAL REQUISITES: drawing and not dirtying.

DRAWING

Reflexions	- %
First modellings	0 %
Light tones	2- 5 %
Middle tones	5-10 %
Dark tones	50-52 %
Deep blacks	50-52 %
Full colour	- %

NOT DIRTYING
Black dirties and does not draw when it exceds 55% in dark tones; it cause enphasis in middle and middle-minimal tones, concept, which is sound for conventional reproduction.
For scanner processings, what conunts is the starting point = 2%, to lay on shodow portions of light tones; this must produce a distinct drawing in middle tones.

PARTICULAR REQUISITES
The characteristics described in the above section, must be obtained by programming in conventional reproduction and by set-up with a scanner, not by dot etching from an emphasized positive which is therefore flat, lacking in middle tone modellings.
Dot etching of black does not make up a drawing, but reduces contrast with definite loss of reinforement modelling, especially in middle-dark tone details.

CYAN MONOCHROME OF TRICHROMATIC SEPARATION

GENERAL REQUISITES: Bright and complete.

BRIGHT

Reflexions	0 %
First modellings	9 %
Light tones	- %
Middle tones	- %
Dark tones	- %
Deep blacks	98-99 %
Full colour	98-99 %

COMPLETE

In comparison with yellow and magenta, cyan must have a higher middle walue, for instance:

C = 65 % M = 57 % G = 60 % (halftone gravure conversion)

C = 65 % M = 50 % G = 58 % (offset).

with well marked and progressive tonal passages.

SUPERIMPOSITION REQUISITE K + C = DRAWING

The drawing must look complete, well stressed, slightly more emphasized than the original, but with overall tonality slightly reduced.

DISADVANTAGES

Overall tonality a little over emphasized compared with the original

Cyan without moddellings in light tones, hence strassed in middle tones because of too much emphasis in the highest. Keep to optimal 98-99%. Cyan flat because stressed in light tones, hence reinforced in middle tones.

Black too strong in the highest, or too stretched in first modellings, hence flat and lacking drawing in middle and middle-dark tones.

Apparently the whole results scarcely sharp.

The middle value of cyan has been expressed by a value below 65% of dot.

MAGENTA MONOCHROME OF TRICHROMATIC SEPARATION

GENERAL REQUISITES: Soft and hollow.

SOFT

Reflexions	0 %
First modellings	6 %
Light tones	- %
Middle tones	- %
Dark tones (UCR 10-15%)	90-92 %
Deep blacks (UCR 10-15%)	90-92 %
Full colour	98 %

HOLLOW

Middle value of original expressed by 65% less Dot Gain 8-6% halftone gravure conversion, 10-15% offset; example:
M = 57 % (halftone gravure conversion)
M = 50 % (offset) C = 65 % Y = 60 %

SUPERIMPOSITION REQUISITE K + C + M = VOLUME

Overall tonality must appear similar to original especially in the neutral middle-dark tones, with passages towards light tones that are really over - emphasized but slightly less stressed than in the original.
Sharpness in general, definition, details must result more stressed and evident in comparison with the original.

DISADVANTAGES

Detail and definition equal to original.

Not kept in Cyan and Magenta 98% corresponding to density D 1.80 for lith processing and MP and D 2.00 for Rapid Access processing.

Middle and middle-dark tonalities stonger than original.

Magenta not well checked in middle walues; 65% less Dot Gain in PRECISE.

YELLO MONOCHROME OF TRICHROMATIC SEPARATION

GENERAL REQUISITES: vigorous and balanced.

VIGOROUS

Reflexions	- %
First modellings	12-14 %
Light tones	- %
Middle tones	- %
Dark tones	- %
Deep blacks (UCR 15-20%)	85-90 %
Full colour	99-100 %

BALANCED

Middle value of original expressed by intermediate percentage between Cyan and Magenta; example:

Y = 60 %   C = 65 %   M = 57 %

OVERALL COMPARISON REQUISITES Y = K+C+M = ORIGINALE

The highest intensities of yellow must correspond to the illuminated areas of original, like in the coloured areas of lemons, oranges, greens and flashes of artificial light. Moderately strong in the reds, about 85-95%. Light but complete in the cyan and generally in the blue.

DISADVANTAGES

Not balanced, too weak.

Pay attention to minimuns which must be precisely $\geq$ 12 % with maximums $\geq$ 98 %.

Not balanced, too strong.

100 % is accepted only for highly coloured areas, otherwise keep to 98-99%; minimums are allowed up to 15%, not more.

CONTROL METHOD*
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OPERATIVE SISTEM**:
SUPERIMPOSITION OF HALFTONE MONOCHROMES

QUADRICHROMIC SEPARATION

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*METHOD Procedure suitable to guarantee, on the theoretical-pratical plane, the functional character and faithfulness of a work or a behaviour.

**SYSTEM Linking up of elements into an organic whole.

BLACK MONOCHROME OF QUADRICHROMATIC SEPARATION (MODELLING)

GENERAL REQUISITES: strong and modelled.

STRONG

Reflexions	0 %
First modellings	0 %
Light tones	2- 5 %
Middle tones	50-60 %
Dark tones	90-95 %
Deep blacks	98-99 %
Full Colour	- %

MODELLED
Black in modelled when it appeare complete, similar to black and white, but with the first modellings comparatively neat. Modelling expresses a balanced relation between the percentages referring to middle and dark tones, reinforced or reduced, according to the U.C.R. percentage employed for the three colours.
The values given are for classical quadricromatic separation with 50% average U.C.R. for the three colours: yellow, magenta, cyan.

PARTICULAR REQUISITES
The characteristics stated for quadrichromatic black are meant for conventional programming or for set-up scanner.
Dot etching is to be avoided in any case since it would impair the drawing, the detail and the image freshness.
Partial retouching is allowed, only if strictly necessary and of scarce importance.

CYAN MONOCHROME OF QUADRICHROMATIC SEPARATION

GENERAL REQUISITES: U.C.R. Value =50% Limit about 1/2.

U.C.R. Value 50 %

Reflexions	0 %
First modellings	9 %
Light tones	- %
Middle tones	- %
Dark tones	50 %
Deep blacks	50 %
Full colour	98 %

LIMIT ABOUT 1/2

The limit specifies the U.C.R. operative starting point; beyond this limit it is likely to occur a reduction in the middle tones colour saturation. Set the limit potentiometer at about 1/2 travel. It works according to the type of original. If the original is mainly cold, i.e. blue-cyan are predominating, it will be better to set the potentiometer at 1/4 travel.

SUPERIMPOSITION REQUISITE K + C = DRAWING

The drawing must appear complete, decidedly stressed, rather more emphasized than the original, but with overall tonality slightly reduced.

DISADVANTAGES

Overall tonality stronger than the original.

Cyan too strong in maximums, hence strengthened in middle tones. Keep better to 98-99% of maximums.

Cyan with marked light tones, therefore flat and consquently with increased middle tones. Keep better to 9% of minimums.

Black too strong or too stretchd. Remake.

Overall result scarsely sharp.

Middle value of Cyan or black below 65%.

MAGENTA MONOCHROME OF QUADRICHROMATIC SEPARATION

GENERAL REQUISITES: U.C.R. Value = 50 % Limit about 3/4.

U.C.R. Value 50 %

Reflexions	0 %
First modellings	6 %
Light tones	- %
Middle tones	- %
Dark tones	- %
Deep blacks	50 %
Full colour	98 %

LIMIT ABOUT 3/4
The starting point of U.C.R. action can be strengthened owing to the considerable power of printing rendering of European scale magenta ink. If the original is warm with remarkable red tonalities, it is better to set the limit to intermediate values.

SUPERIMPOSITION REQUISITE K + C + M = VOLUME
The general tonality must appear similar to the original, particularly in the neutral middle-dark tones with over-emphasized passages to light tones more evident than in the original. Generally sharpness, definition, details must result more stressed and evident compared with the original.

DISADVANTAGES
Detail and definition equal to original.
Maximum strenght not kept in cyan and/or magenta, 98% equal to D 1.80 for Lith or MP and D 2.00 for Rapid Access.
Middle and middle-dark tonalities stronger than the original.
Magenta not well checked in middle tones, 65% less Dot Gain is PRECISE.

YELLO MONOCHROME OF QUADRICHROMATIC SEPARATION

GENERAL REQUISITES: U.C.R. Value = 50% Limit about 1/4.

U.C.R. Value 50 %

Reflexsions	- %
First modellings	12-14 %
Light tones	- %
Middle tones	- %
Dark tones	50 %
Deep blacks	50 %
Full colour	98-100 %

LIMIT ABOUT 1/4

The effect of U.C.R. action must be limited in the yellow to the blacks only, with minimum of action on colour saturation, not to lessen the overall brightness effect. For the originales with dominant greens and reds as well as overall yellow predominance, limits are cancelled.

OVERALL COMPARISON REQUISITES Y = K+C+M = ORIGINAL

The highest intensities of yellow must correspond to bright areas of the original, except in neutral and deep blacks. The maximum value will be kept also in the coloured areas such as in lemons, oranges, greens and flashes of artificial light.

DISADVANTAGES

Too weak.

Pay attention to minimums which must be precisely >= 12 % with maximums >= 98 %.

Too strong.

100 % is accepted only in highly coloured areas, otherwise keep to 98-99%; minimums are allowed up to 15%, not more.

GLOSSARY OF TONAL GRADATION

REFLEXIONS:

Small areas without modelling, un-coloured, consisting of white paper.

FIRST MODELLINGS:

Beginning of modelled area apparently, white but made up of three colours, with the typical chromatic composition required by the three inks used in printing, such as European scale:

C = 9 % M = 6 % Y = 12 % K = 0 %

LIGHT TONES

Areas rich in modelling and with a high readability, the most important of the whole tonal range in order to express an image. They make up most of complexions. Neutral composition of this tone either are as such or even the slightest shift of chromatic composition, visuall determines a remarkable predominance.

MIDDLE TONES

They are the linking elements between the light areas and the dark ones. They are the areas that most undergo huge distortions at the moment of printing, therefore they must be kept under strict control in reproduction.

Their exact translation in dot percentage, not only assures a fair tonal rendering, but also gives sharpness and detail to the whole reproduced image.

DARK TONES

Areas apparently slightly coloured or neutral, generally overlooked because of confusion with deep blacks.

In reproduction these tonalities must have marked and balanced modelling. It is not easy to get it or increase it, but any step in this sense will improve and qualitatively characterizes the reproduction.

DEEP BLACKS

Areas without modelling, having highest blackening and hence maximum printing strength, glossy to guarantee maximum absorption of incident light. The deeper these areas are, the more the other tonalities stand out, especially the light tones. They are therefore the major responsible factors for the overall "brightness" of the image reproduced by printing; deep black is obtained with full black (100%) plus a reinforcement of 50-70% of cyan. In quadrichromatic separation:

C = 50 %   M = 50 %   G = 50 %   K = 98-99 %

FULL COLOUR

Areas with highest printed ink saturation value (100%): they must result even, not stained or with printing mechanical defects or crease. This area must not be mistaken with that near 98-99% of dot, even if apparently they look the same. They will be differentiated only with the modelling colour:

Yello for Blue (M + C)

Magenta for Green (Y + C)

Cyan for Red (Y + M)

APPENDIX N° 2

DATA PROCESSING IN DIGITAL IMAGE FOR PRINTING REPRODUCTION TECHNIQUES

The idea of studying and translating this subject into a mathematical model belongs to lecturer Enrico Santi teacher at Centro per la Formazione Professionale Grafica San Zeno, Verona (Italy).

He worked particulary to the equational mathematical solution with all possible scientific rigour, but particularly oriented to a practical solution of the complex problem: TONAL GRADATION - CHROMATICISM OF THE PRINTING IMAGE.

The test and study of the quality rendition, the adjustment for the utilization and pratical study was carried out by a team composed of Enrico Santi, Pietro Chasseur and teachers of the Applied Research Centre at Centro per la Formazione Professionale Grafica San Zeno, Verona (Italy).

The object of the study was to achieve the optimal equality (qualitatively acceptable) between original copy and printed result, making this transformation by the available means, assisted by a computer.

Starting from the didactic need to explain the complex problem of obtaining again a given quality, in printing conditions, following customer's requirements, working with the available material and equipement and with an informatics mentality, i. e. following and enumerating the procedures with specific flow charts, elaborating mathematically each partial passage, in a few years, a resolutive analysis has been piled up such as to be transferred into a single model to be processed by a computer.

The mathematical model we have drawn up, can supply the percentages of printed dot required to obtain again the required visual effect. From these data, we can go back to the dot percents required for the positive halftone, all starting from the densitometric values read on the original.

The main equation is based on three SUBROUTINES capable of guaranteing the chromatic balance of the separation (composition of neutral gray), supplying the requested percent composition of CYAN, MAGENTA and YELLOW inside a linear tonal gradation, i.e. proportional and with gradient characterized by the printing conditions.

By this mathematical model the BLACK is not collected from the colormetric characteristic of the image point, but is now pre-stated according to the peculiar printing needs. The pre-constitution of the blacks starts with the trichromatic-printing, reinforcement of the depth of images and then goes on with progressive characteristics that can vary according to the percentage of U.C.R.

Once black is determined, the equation forecasts the adequate proportional reduction of the three colours, before calculating the chromatic balance that leads back to neutral gray.

The tonal gradation, previously chosen, has given to the data to be processed the information of shift from linearity, acting continuously and proportionally on the tonal areas 1/4, 1/2, 3/4, starting from the maximum and minimum set-up points. This possibility, wide and dynamic, permits to modulate the output tonal gradation, according to the printing process and to the characteristics of the originals to be reproduced. In this connection, there are a series of functions or specific programs, subdivided for OFFSET needs and GRAVURE needs, and, inside these two groups, programs for normal originals, either contrasted or very poor in chromatic tonality. The choice of a program rather than another depends on the operator's will, only limited by quality rendition or by the impossibility to re-obtain it with the present scanners.

A characteristic of this mathematical model is the possibility to make the mentioned choices by a single proof printed on good paper. The printing conditions that have been memorized, will then affect the shifting of middletone, in order to rebuild or at least improve optimally the contrast rendition of the print.

The possiblity of using this software can be summarized as follows:

a) standardized pre-setting of scanners, in order to guarantee repeatability and even rendition in production, also with scanners of different generations, but what is more, of different makes;

b) aid to scanner operators in both pre-set and set-up functions, especially in case of critical originals, new orders of different kind, little experience or during training stage. It has proved particularly useful for the control of positives or negatives obtained by scanner;

c) simulated study of quality rendition with changing printing conditions, for training, technological research, increase of practical experience;

d) possible utilization in the treatment of digitalized images when loaded on computer $\geqslant$32 bit.

It is still too early to discuss the limits of this mathematical model, but like all informatics applications, more is to be imputed to lack of will, fantasy and cleverness, than to poor processing possibility of computers.

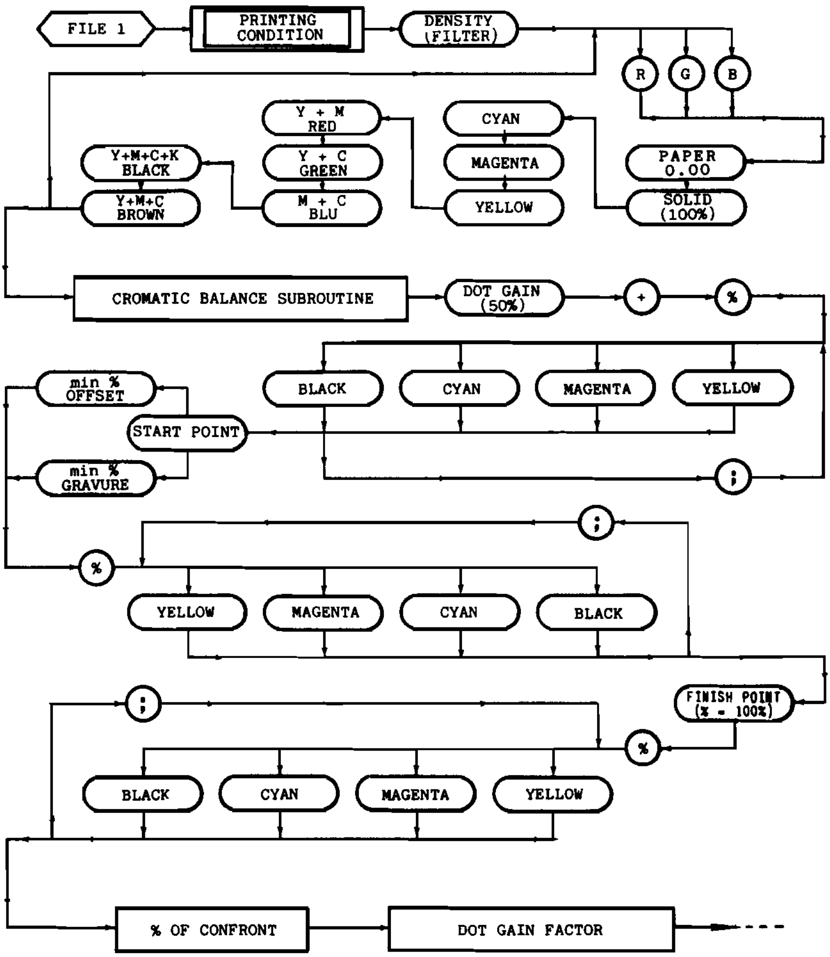
We particularly aimed at simplicity of use, which distinguishes this study, and that can be employed with any type of computer, provided it has enough capacity. We intend to continue to use it intensively either in re-training or first-education; therefore the suggestions of the users will be not only useful but also extremely appreciated for cyclical up-dating.

According to the short experience we could make, we believe that this soft can be used in various applications. In our evaluation it has particularly stood out in the prefiguration of the final quality of a printed image, as well as in the speed and ease of composing programs for offset or for gravure with a scanner.

We give hereby 4 syntactical diagrams, useful for a greater clearness of the algorythmic practice employed, together with some significant examples of data processing obtained with a small-sized computer.

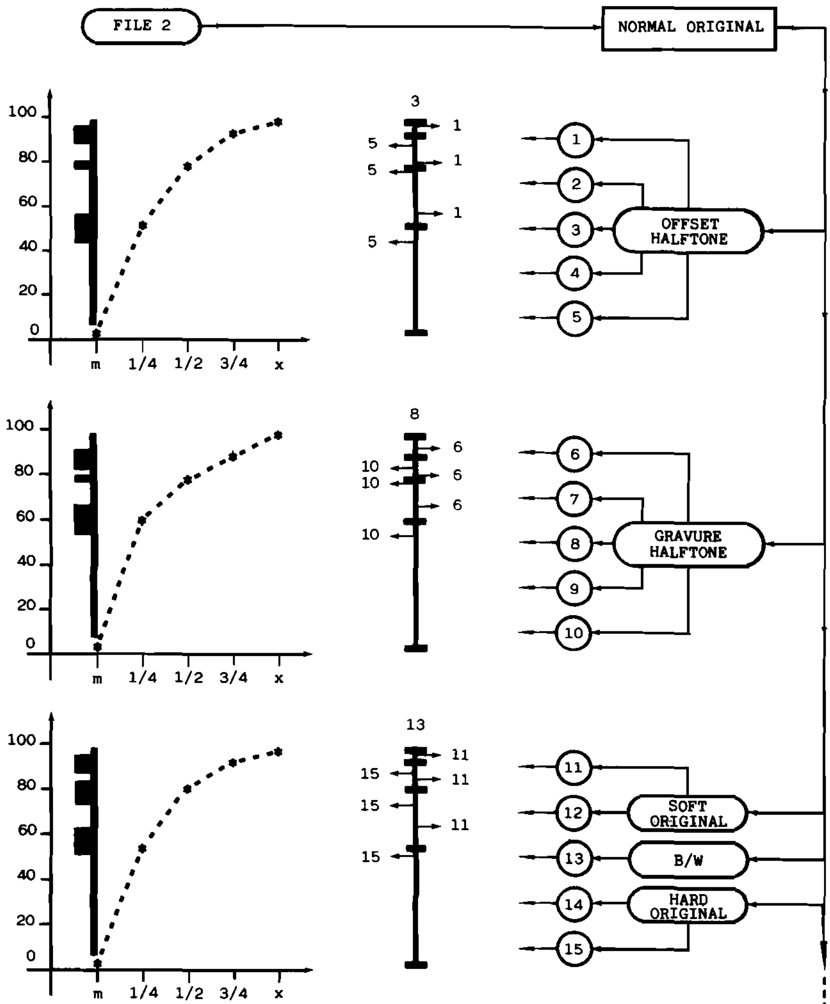
DATA PROCESSING OF DIGITAL IMAGE

FILE 1° = PRINTING CONDITION ANALISIS



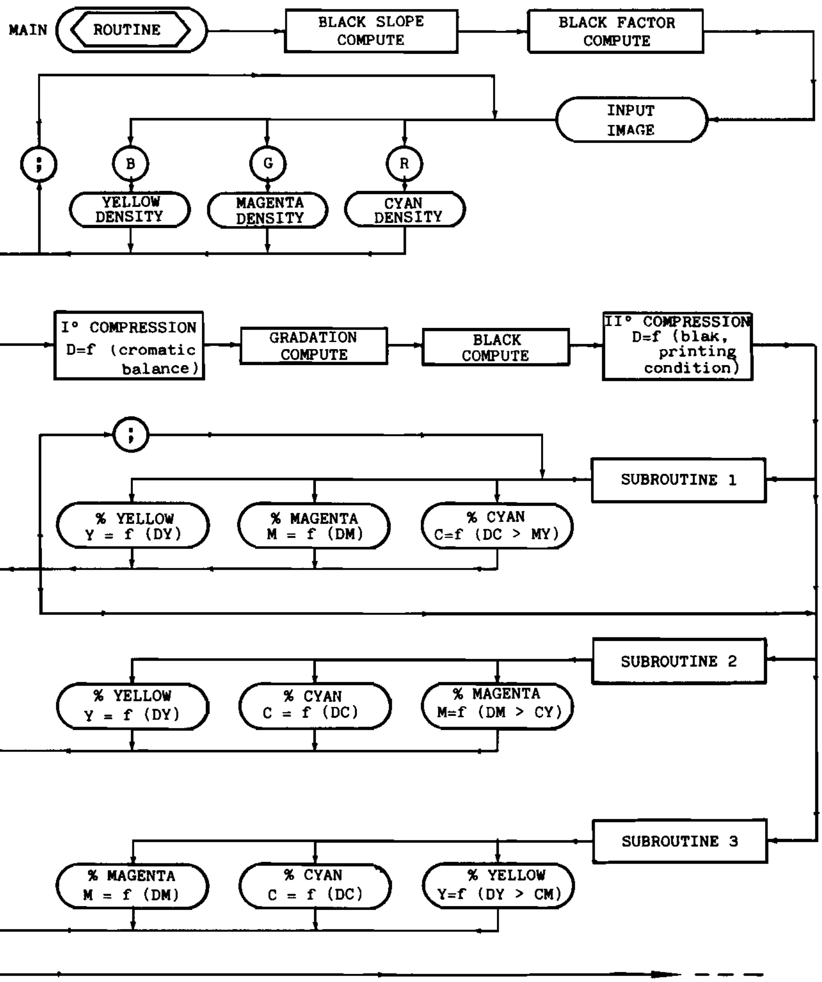
DATA PROCESSING OF DIGITAL IMAGE

GRADATION OPTION FOR OFFSET/GRAVURE AND B. & W.



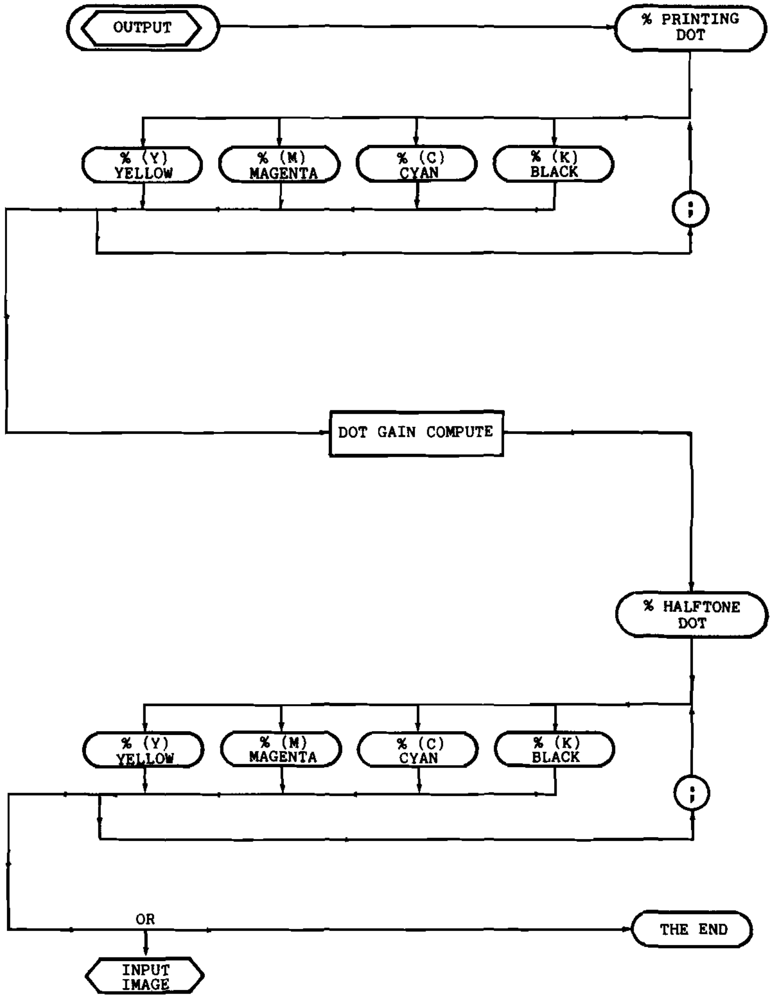
DATA PROCESSING OF DIGITAL IMAGE

INPUT IMAGE AND MAIN ROUTINE



DATA PROCESSING OF DIGITAL IMAGE

OUTPUT OF DATA



1984/04/26 8.5557
TEST/TAGA 84 BOS
(D) CONVERTER> (%)
SLOPE> 1 UCR> 0
Dmax 2.60 min 0.35

FOREHEAD l./girl
INP>-<R>--<G>--<B>
ID> 1.06 1.43 1.75
CD> 0.57 0.88 1.15

OUT>---<H>----<P>-
<K>> 1.78 3.03
<C>> 63.28 72.62
<M>> 72.49 81.82
<Y>> 84.32 89.77

JACKET cen./girl
INP>-<R>--<G>--<B>
ID> 0.95 0.90 1.07
CD> 0.41 0.37 0.49

OUT>---<H>----<P>-
<K>> 0.00 0.00
<C>> 50.76 60.76
<M>> 29.29 38.81
<Y>> 47.54 57.49

CHEEK cent./girl
INP>-<R>--<G>--<B>
ID> 1.15 1.75 2.06
CD> 0.65 1.17 1.44

OUT>---<H>----<P>-
<K>> 3.40 5.69
<C>> 68.84 77.46
<M>> 86.83 92.26
<Y>> 93.34 96.21

CHEEK right/girl
INP>-<R>--<G>--<B>
ID> 0.88 1.48 1.80
CD> 0.44 0.94 1.21

OUT>---<H>----<P>-
<K>> 0.00 0.00
<C>> 51.64 61.65
<M>> 77.71 85.80
<Y>> 86.55 91.40

BOTTOM into girl
INP>-<R>--<G>--<B>
ID> 1.12 0.98 0.94
CD> 0.53 0.44 0.41

OUT>---<H>----<P>-
<K>> 0.00 0.00
<C>> 62.18 71.63
<M>> 34.11 44.74
<Y>> 34.49 43.09

COAT right girl
INP>-<R>--<G>--<B>
ID> 1.14 1.10 1.30
CD> 0.58 0.55 0.70

OUT>---<H>----<P>-
<K>> 1.33 2.26
<C>> 64.72 73.89
<M>> 44.05 55.90
<Y>> 61.26 70.79

LOW BOTTOM l/c/g
INP>-<R>--<G>--<B>
ID> 1.34 1.18 1.10
CD> 0.74 0.61 0.55

OUT>---<H>----<P>-
<K>> 1.44 2.45
<C>> 75.42 82.90
<M>> 49.63 61.63
<Y>> 42.59 52.24