Dot Gain, What is the problem?

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Introduction:

Whilst it remains undoubted that the measurement of dot gain for printing production control can only be made conveniently by densitometer, many results from Research projects and from recent papers would suggest that a wide variability can be created in the generation of the original or standard number for calibration.

It is well known that variables exist in the measurement of half tone values by densitometer in terms of paper surface, wet or dry ink, paper grain direction and in densitometer characteristic, whether wide or narrow band filter, polarized or not and the age or type of densitometer.

It was reported by Milton Pearson TAGA (1) that the Murray Davies equation gave reliable results when used for transmission measurements on non-scattering materials. The topic of the paper was to explore the establishment of a mean number of·1.7 for the Murray Davies equation for printed results accepting however that this can only be an effective compromise between convenience and accuracy.

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Introduction (Continued)

It has become necessary to look more deeply into the creation of geometric standards when measuring the condition of the halftone screen from film to final print. One of the first recent practical examples of the conversion of geometric standards to densitometer was in the control of dots in the process of whole page facsimile transmission for Newspapers and Magazines produced simultaneously in satelite printing plants.

An instrument exists which was designed to produce a geometric dot percentage value and the Planimeter is increasing in use within the United Kingdom to produce the transfer standard information for press and process control densitometers.

When discussing dot gain as a percentage value whether it be change through process or differential change throughout the tonal range there would appear to be many views as to the standard or known condition from which the measurement value can be is projected.

In the absence of a firm base number using the Yule Neilson equation, it would appear that much discussion and disagreement exists when a number of measurements are made by different people on the same subject. When a value which has been provided by geometric measurement is used as the basis for densitometer calibration and instrument to instrument agreement, the practical experience has been one of greater measurement security.

Review of Dot area, Percentage tone measurement Cut and Weigh.

Still a much used field system for dot percentage, value determination is the cut and weigh principle. A photomicrograph is taken of the area to be measured at a fixed and known magnification. Typically a magnification of x 100 is used with a Projectina projection microscope. Five or more photographs are taken of the image, the number depends on the screen ruling and dot size so that sufficient sample can be taken in order to produce an accurate mean result.

The black and white areas are very carefully cut and separated from the dried photomicrographs. The cutting process is followed by weighing the black and white areas separately on an analytical balance and by simple calculation arriving at the percentage of black and white material from the original area.

Naturally this process is extremely time consuming and puts heavy demands on cutting accuracy. It does not need saying that this is no process for the Production Printing or Process plant.

Print Planimeter.

The original Print Planimeter was designed and used out of necessity by PIRA in the United Kingdom as long ago as 1969 and is described by A E Bardouleau and S S Hitchcock in their paper, "A device to measure printed dot area employing vidicon scanning technique"(2)

The pressure to produce an alternative system of measurement to cut and weigh was caused by the need to measure accurately a very large number of samples for an investigation into dot growth in lithography.
The original Planimeter tool for Research was found to be highly successful for dot area measurement and gave good resolution throughout the range of values particularly in the extremes of below 10% and above 90% dot area where other optical methods had shown poor discrimination.

The main deficiency of the original instrument which was perpetuated into the early commercial instruments was the need to make operator decision on the various fringe, spread or uneven characteristics of the lithographic halftone dots being examined. The threshold for the blackest black and the whitest white was achieved by manually targeting cross hairs on regions which the operator decided in his judgement related to these extremes.

On the current commercial Planimeters the manual thresholding by cross hair targeting exists only as an option and the decision for blackest black and whitest white is arranged through automatically extracting high and low densities and electronically processing a threashold condition.

<u>Principle and Operation of a Print Planimeter.</u>

The current commercial Planimeter Beuvac Mark 111 measures geometric dot area by means of scanning a halftone image at any stage from film positive, negative or bromide through plate to final print.

The screened information is converted from reflection or transmission copy through a lens and filter system to an image on the vidicon screen of a video camera. The optical image produced in this way has undergone the normal fixed time base scanning process. The optical image undergoes a sequential horizontal scanning in its creation which begins at the top and runs to the bottom of what is determined to be the measuring area, this is electronically set up onto the vidicon screen. Accepting a fixed distance between the scan lines and a fixed time base for scanning, the measured area can be divided into high and low density areas which provide in turn the basis for a computed calculation of dot area.

FIGURE 1

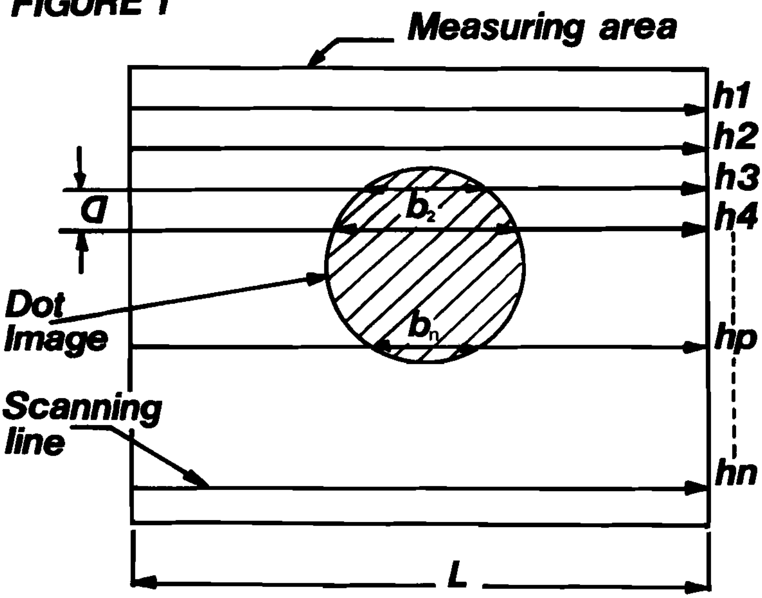
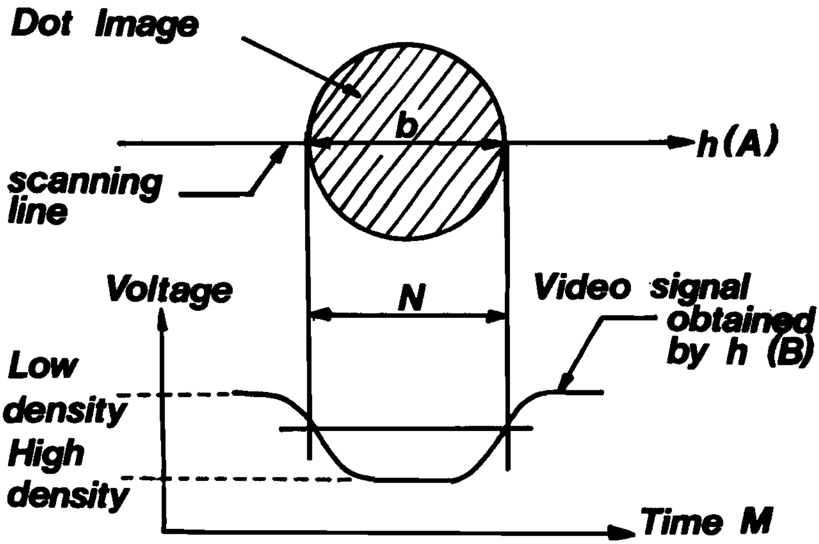


Figure 1 shows the determined measuring area with one dot used for illustration only. In practice a number of dots will be measured and calculated simultaneously. The measuring area is scanned as represented by h1 to hu. from top to bottom in equal scan widths. The ratio of high and low amplitudes produces a geometric value proportional to the white, unprinted, and black,or printed dot which can be converted into a digital signal and displayed as a percentage. The same process is true for transparency, positive or negative; printing plates planographic or relief; separated process colour or black prints; or superimposed three colour prints.

Figure 2 shows in the top portion an image of one dot with the scan line (h). The lower portion shows a representation of the video signal obtained after conversion.

The horizontal axis of B represents the scanning time of the video camera and is proportional to the length of the dot image A.

FIGURE 2

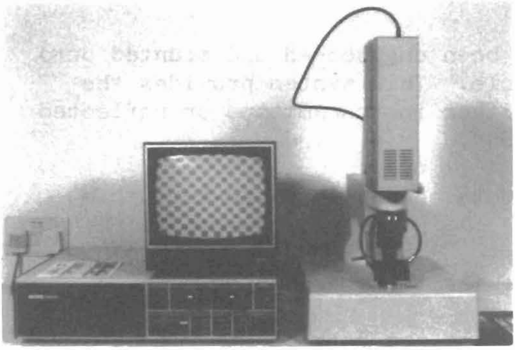


The vertical axis of B corresponds to the voltage which is proportional to the optical density of the image in A.

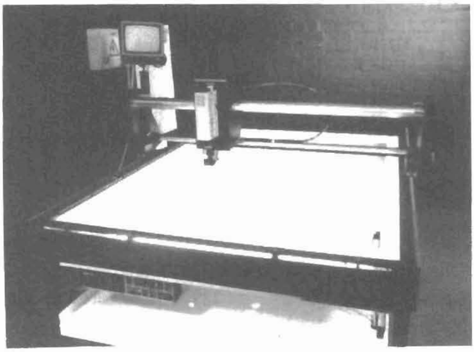
Taking the above known conditions, the dot to no dot percentage can be calculated by a formula based on the clock-pulse (N) which corresponds to the length (b) of the dot image and the total scantime (M).

The decision between dot and no dot is the subject of automatic thresholding but the system can be manually overidden by means of two superimposed cross hairs to decide the influence of film grain or imperfect printed dots.

A more complete explanation of the principle of the planimetric dot area generation is contained in the PIRA publication previous mentioned although the automatic thresholding represents a later development. The operation manual for the Beuvac 3 provides full information on automatic threasholding (3).



Standard Bench Planimeter



Planimeter - XY large format base system

Applications

Previous reference has been made to the original pressure of high volume measurements of printed dots which led to the developement of planimetry by PIRA, however the use of this system of dot measurement has only within the last five years found acceptance for the measurement of more complex aspects of the printed dot in the Graphics Industry. Practical applications are is also being found in the generation of standard norms for the calibration of densitometers for high volume production control measurements. The currently available Planimeter can best be described as a Laboratory or Standard number generation instrument but not so readily as a tool to be used in the production environment. Although fairly simple to operate the requirement for cleanliness and freedom from dust or stray particles in the lens system and viewing path requires a reasonably clean atmosphere.

Cartography

A recent development for large format map measurement from film to print, takes the planimeter out of the Laboratory into the Photomechanical area of production.

A modified planimeter has been engineered and mounted onto a high precision X - Y table. This system provides the facility of measurement either in transmitted or reflected mode to a total of 70" x 50".

Three valuable pieces of data can be obtained from this system:

1) The geometric value of the transparency or printed dot.
2) A 100 x magnified image of the dots on the video monitor.
3) By using the tri-stimulous filters on multicolour printed maps it is possible to detect whether or not certain colours are printing and to measure the area dot.

Newspapers

The successful use of planimetery has been made in United Kingdom and European Newspaper Production Plants for the control of dot size in facsimile transmission of whole page data to satellite plants.

Planimetric measurement was used by the Daily Mirror in the UK and Der Tages - Anzeiger in Zurich with drum Facsimile transmission scanners where it was found that bromide or transparency dots of less than 0.005" were invariably lost in transmission and this resulted in total loss of halftone highlight which could not be tolerated in Letterpress rotary printing.

More recent developments in flat bed whole page transmission equipment reduced to a large extent the dropped dot phenomenon although where the transmitted result was to be used on photopolymer letterpress conversion it was still possible to lose highlight dots where different screen generation processes were used. Notwithstanding the significant developments in whole page facsimile transmission, the use of geometric dot measurement by planimeter is still found to be vital in establishing minimum dot size threasholds to be achieved on the copy for scanning and transmission through conversion processes to the final printing plate whether letterpress or offset litho.

In this case up to eight X-Rite densitometers are lined up with the planimetric achieved values. Before we explore the creation of transfer standards to densitometer, perhaps it would be as well to look at the nature of dots which must be measured in order to control the basic elements of halftone Printing.

A selection of image characteristics with which planimeter and densitometer must contend are illustrated at the end of the paper.

We are here considering dot gain which is known to be a complex combination of elements of measurement of which one aspect is geometric dot percentage. As a measurement by densitometer, suitably arranged to measure dot gain and dot percent, the values represent the halftone screen resolved as a point on a tonal scale most closely agreeing with the anticipated response of the human eye. Since it can be shown as in the previous illustrations that dots presented for densitometric examination have a considerable range of forms and characteristics, it can be shown that the establishment of a geometric number would be at least helpful in providing a basis for calibration.

Densitometer Standards.

The use of a Planimeter in the Qualtity Assurance Area is complimented by the densitometer for Qualtity Control applications.

Densitometry is established for the measurement of dot gain in a printing environment. In a complex image transfer environment such as a modern newspaper or magazine plant the use of planimetry is valuable in the establishment of standards which can then be used in conjunction with densitometry as a means of routine production control.

Image Transfers.

In a many operational environments image transfers can be numerous including

- The production of digitally imaged screen prints
- "page" negatives
- transmitted images for distribution
- The facsimile reception of positives and negatives
- The use of a variety of imaging materials.

It may be seen from the illustrations that the structure of the images is not necessarily regular and thus can lead to distortion and discontinuities when measurement and control by densitometry is attempted. This could lead to confusion in the determination of an optimum operating proceedure.

In these circumstances it is preferable to establish objective measurements by means of planimetry and then use densitometry via a transfer standard for control.

A transfer standard, in this context, is an image which has been objectively measured by planimetric means and has been found to satisfy the subsystem or performance criteria of the production operation.

It is emphasized that there are two standards which must be co-ordinated in the following order:

- Operation Standards
- Performance Standards

An Operation Standard is the external control for an operation or subsystem.
This is exemplified for instance by

- film processor control standards
- the control of image structure in digital imaging

Once these subsystem factors are controlled the performance standards are established by planimeter and can be measured and used for production control.

As an example, the imaging characteristics of a transmission system may modify the structure of the image and distort the transfer characteristics at the printing plate production stage. Having optimised and accepted this effect suitable standards are designed and stabilized.

The standard image is then measured using a densitometer. The measurements are used for production control and will give early warning of change which is more closely investigated by laboratory planimetry.

Systems.

The foregoing emphasizes the fact that current imaging processes must be considered as a co-ordinated structure of subsystems which must be individually controlled and stabilized before effective performance can be established and controlled.

Conclusions.

The development of improved and novel
- imaging systems
- image scanning and transmission
- image reception
- production systems

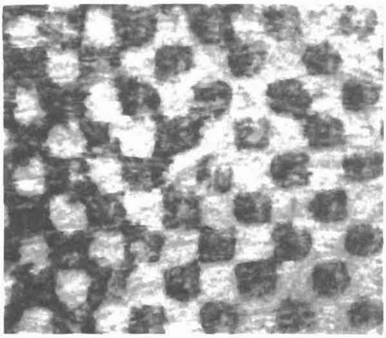
Are expected to require a greater degree of understanding and the complimentary combination of planimeter and densitometer offers an opportunity to understand the mechanisms involved, optimise and control them.

Fortunately the technology exists and perhaps one of the aims of this paper is to draw attention to the Industry led employment of a relationship between techniques which only superficially use the potential of this instrument partnership.

References.

1) Milton Pearson, Rochester Institute of Technology in value for General Conditions.
   TAGA Proceedings 1980 pp 415-425.
2) A.E. Bardonlean & S S Hitchcock.
   PIRA. The Research Association for the Paper & Board, Printing and Packaging Industries.
3) Beuvac 3 Operation Manual
   Toyo Ink. Japan.

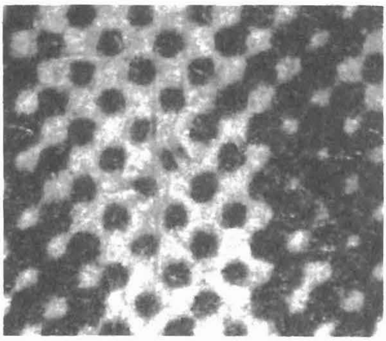
Image Structures - 1



Letterpress Printing

on

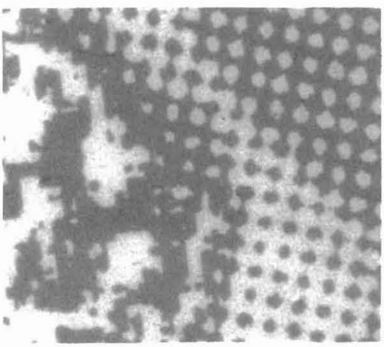
Newsprint



Photopolymer Printing

on

Newsprint

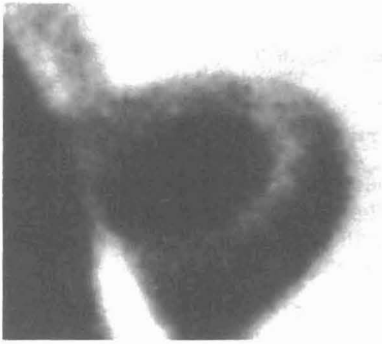


Discontinuous

Image

Structure

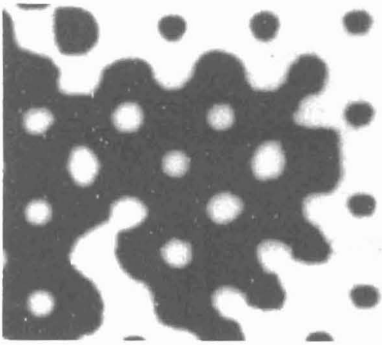
Image Structures - 2



A continuous

Photographic

Image



Electronic

Dot Generation

on

Photographic Paper

A

Screenless

Image