A Rationale for Gravure Etching and "Systematized Single-Acid Etching"

By Harry Baskerville
McGraw Colorgraph Company, Division of Carnation Company

THE purpose of etching is to produce cells of various volumes in copper. The volumes required are those which will transfer such quantities of ink to paper that reflection densities of the proof are as faithful to the transmission densities of the continuous-tone positive (less .35) as the ink and paper will allow.

Traditional etching employs a series of decreasing Baumés in the belief that equal density differences in the positive should be "opened" at equal time intervals to achieve the desired tonal scale in the proof.

Uncritical acceptance of this assumption is challenged by the excellent cylinders and plates which have long been produced by single-acid etching.

In single-acid etching, equal density differences do not open in equal time intervals—they open in logarithmic time intervals.

We submit the following facts and propose a rationale for gravure etching.

Photographic Characteristics of Carbon Tissue

A STEP wedge (densities .35 through 1.65) is exposed to arc light 1x, 2x, 4x and 8x on unscreened carbon tissue. A similar set of exposures is made with Black Light.

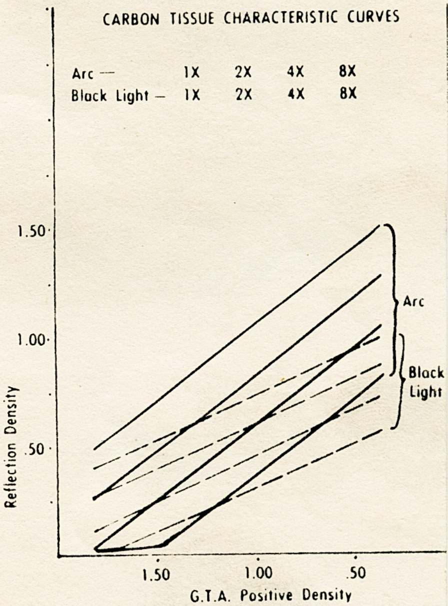

Fig. 1

The carbon tissue is then mounted on plastic (rather than copper) and developed, transferred to (gelatin coated white paper* and dried. Reflection density readings are made and plotted against the step wedge transmission densities. See Figure 1. Note the straight

*McGraw Colorgraph Soluble Support Paper.

(Reprinted, by permission, from September 1966 G.T.A. BULLETIN)

lines, the absence of toe, and that the horizontal displacement of the curves is precisely .30; carbon tissue behavior is strictly orthophotic, and there is no reciprocity law failure. The bottom curve in each set intentionally demonstrates true underexposure. Note the much lower contrast of the Black Light reflection density curves. (We shall return to this later.)

Gelatin Wedge Characteristics of Carbon Tissue

In practical gravure, the gelatin thicknesses produced by the continuous-tone positive range between extremes of approximately 1/10 micron and 20 microns. A logarithmic exposure series made to produce this range reveals that the thicknesses do not increase in an arithmetical fashion, but tend to a logarithmic curve. See Figure 2. Since densities are, by

CARBON TISSUE
GELATIN THICKNESS VS REFLECTION DENSITY

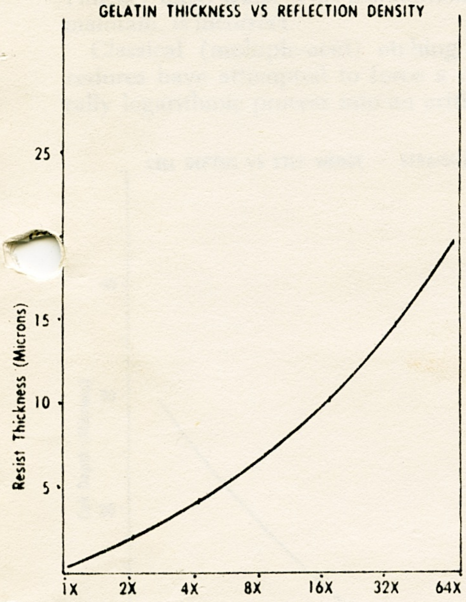

Fig. 2

definition, logarithmic, a properly calibrated continuous-tone positive will produce gelatin thicknesses which fall precisely on this curve.

One Baumé or "Single-Acid" Etching

If the same series of step wedge exposures used for the reflection density curves (Figure 1) are given to screened carbon tissue and these are etched in a single Baumé of ferric chloride, the opening times plotted against the step wedge densities will be found to be logarithmic. See Figure 3.

This fact is further verified by replotting the opening times on a logarithmic time scale. Except for the true underexposure represented by the lowest curve, the curves tend toward straight lines. See Figure 4.

Cell depths plotted against step wedge densities (for "medium" exposures) produce an essentially straight line. See Figure 5.

Reflection densities of a proof printed from an etching of linear cell depths plotted against the step wedge densities produce a straight line (except for the inevitable roll off of all reflection copy as reflection density infinity is approached). See Figure 6.

OPENING TIMES—SINGLE-ACID ETCHING

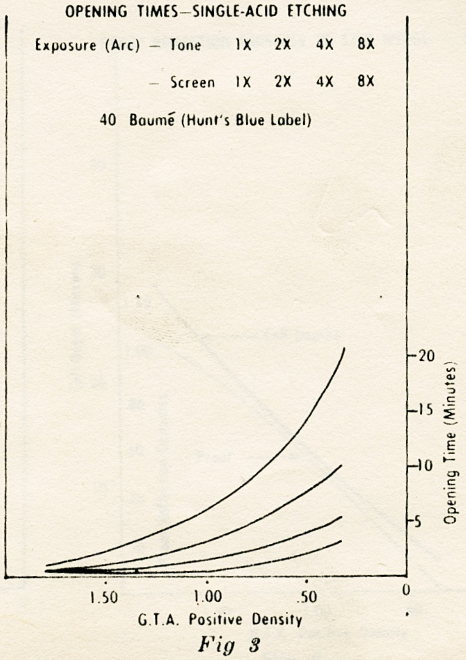

Fig 3

Significance

THE foregoing facts make proofs from cylinders etched in a single acid the only step in the graphic arts which is linear right down to the paper white.

No tonal correction is required for the etching process itself. The tonal limitations that exist are dictated by the ink and paper stock.

(Newsprint limits the reflection density range to about 1.20. Any good glossy photograph will produce a reflection density range of 1.80.

(Gravure, printed with glossy inks on glossy stock, can readily produce a reflection density range of 2.00).

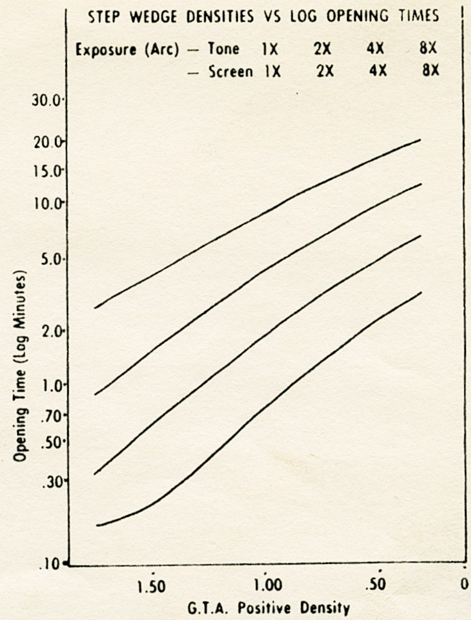

Fig. 4

Error in the Classical Etching Concept

MULTIPLE-ACID etching is based on the assumption that arithmetical opening times are required to achieve a desirable (linear) tonal scale. This assumption, we maintain, is incorrect.

Classical (multiple-acid) etching procedures have attempted to force a naturally logarithmic process into an arithmetical mold, with the following consequences:

1. High-numbered starting Baumés contain insufficient water to allow the

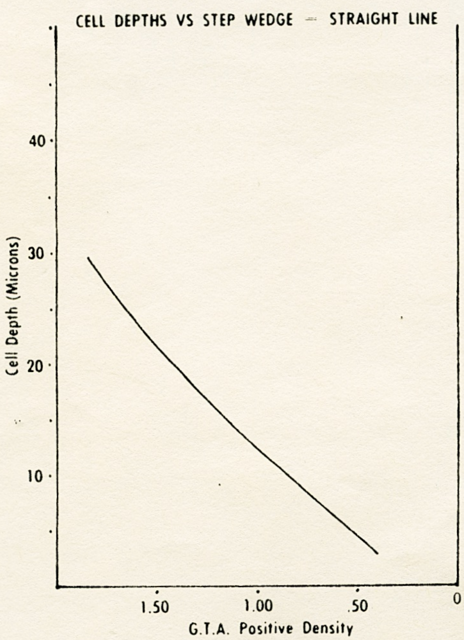

Fig. 5

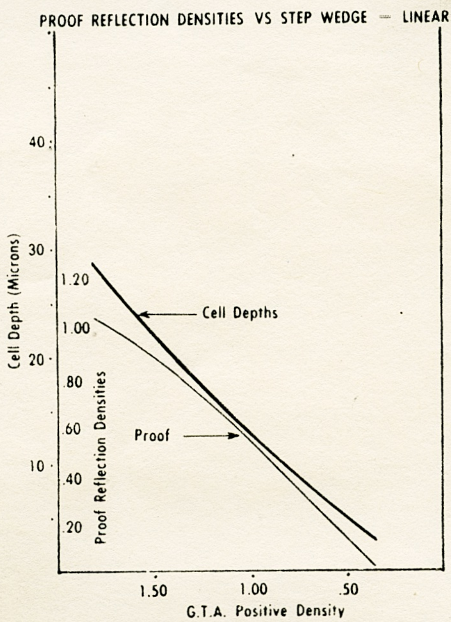

Fig. 6

gelatin to stretch and to lie in intimate contact with the bottom of the etching cell.

The ferric chloride etches the copper out from under the gelatin, rapidly

SHADOW (SOLID) CELLS TYPICAL OF ROUGH ETCH AND SHADOW REVERSAL

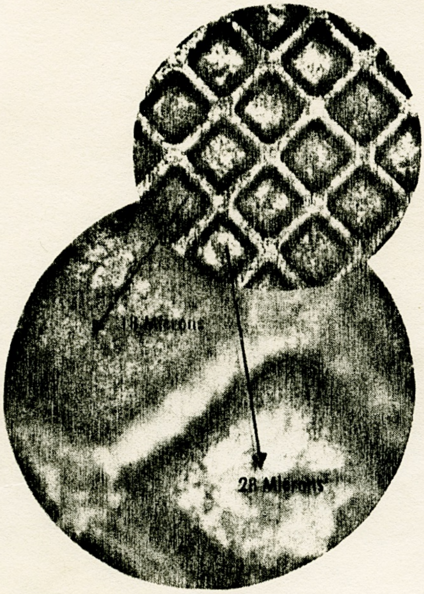

Fig. 7

TONE REVERSAL

Screen Only (opened at 15″ in 44° Baumé) 28 Microns

1.65 Solid (opened at 1′-30″ in 40° Baumé) 38 Microns

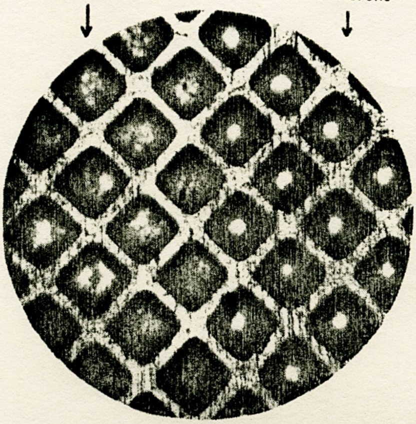

Fig. 8A

becomes spent, and the etching rate is inhibited; rough cells and/or tonal reversal in shadows can result.

See Figure 7 and Figure 8A.

Continuous-tone etching can be done with single acid, which demonstrates that gelatin maintains copper contact throughout etching. See Figure 8B.

2. Shadow contrast is depressed. See Figures 9A and 9B.

3. Middle-tone contrast is exaggerated.

4. Low-numbered irons are required to close out the highlights. Low-numbered irons result in:

   a. Loss of contrast in highlights.

   b. Etching "breakthrough"—etching occurring in areas which were not intended to be etched at all.

   c. "Dark Halo"—nonuniform opening and etching of high key tones surrounding heavily etching areas. See Figure 10.

Systematized Single-Acid Etching Exposure/Baumé Curves

To interrelate carbon tissue exposure, opening times, sinking time and cell

SINGLE-ACID CONTINUOUS-TONE ETCHING

(No Screen—that is, gel maintains intimate contact with copper throughout etching operation)

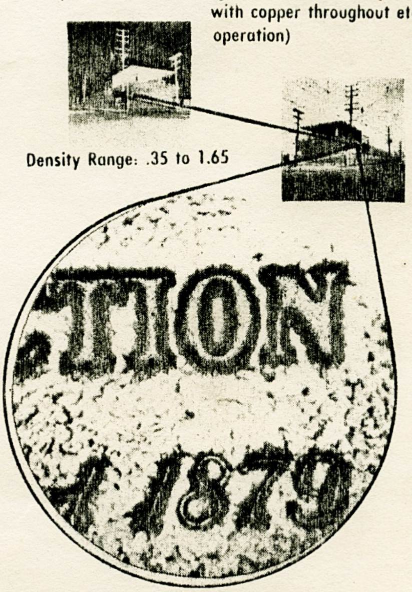

Fig. 8B

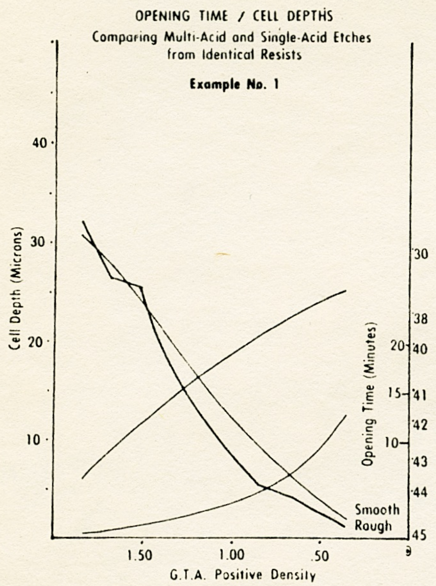

Fig. 9A

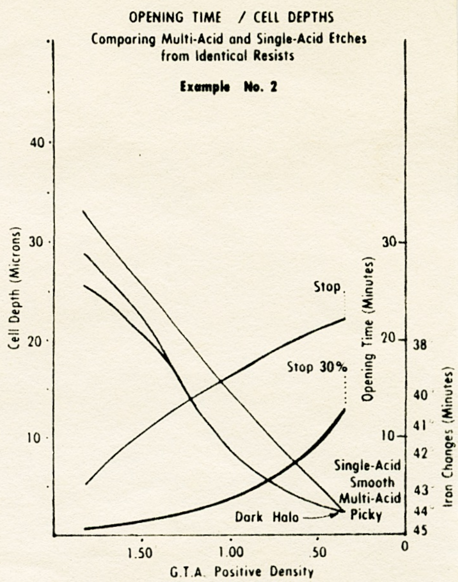

Fig. 9B

depths more clearly, we take exposure/opening time curves (Figure 3), exposure/cell depth curves (Figure 11), combine them (Figure 12), and call them "Exposure/Baumé Curves."

An extremely interesting and important fact emerges. If we will make the highlight sinking time a fixed proportion (percentage) of the total time it takes the highlight (.35) step to open, highlight cells will be of a fixed depth (in this case, 30 per cent equals two mi-

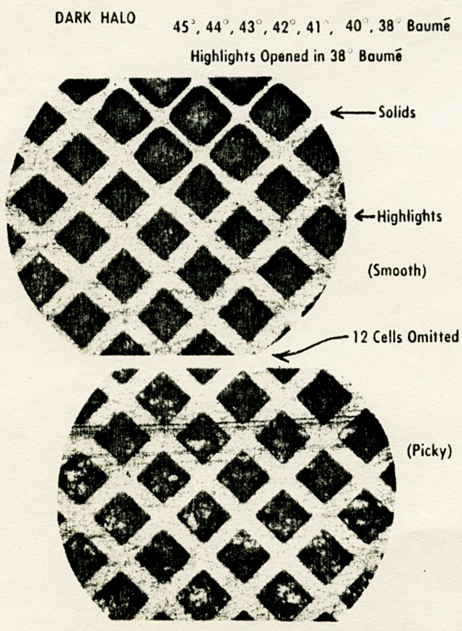

Fig. 10

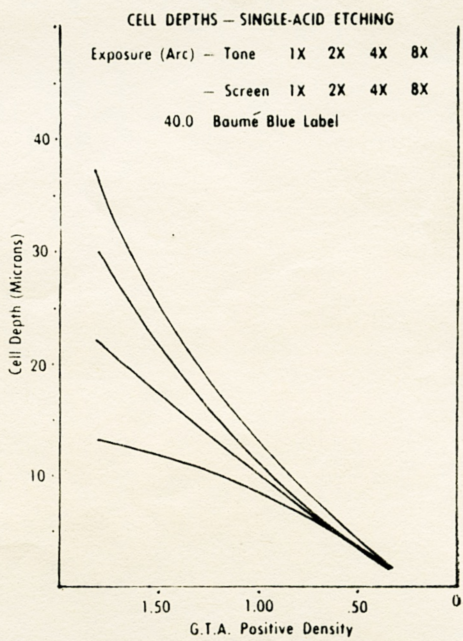

Fig. 11

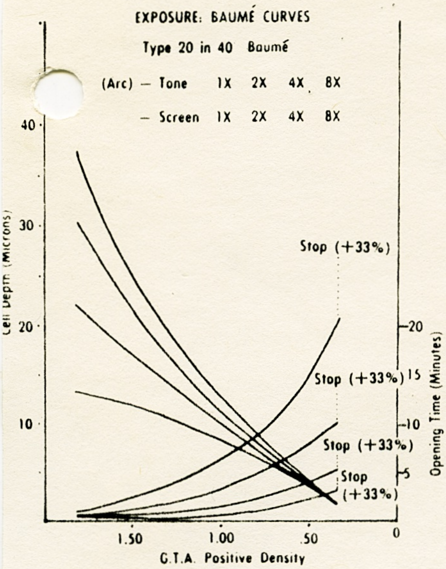

Fig. 12

crons) regardless of the duration of the etch.

Using the same carbon tissue exposures, but different Baumés, other Exposure/Baumé charts are prepared.

Notice that, as Baumé is increased, the pattern of opening times and cell depths rises, but that the same character of curves persists. Figures 12, 13 and 14. Figure 15 is Black Light in 40.5°

Note that the cell depth curves are steeper than would be expected from reflection densities (see Figure 1).*

"Sinking Time Curves"

By preparing four identically exposed and simultaneously processed resists (Figure 16) and cutting them apart so that they can be etched simultaneously but stopped separately, we can determine the effect of various sinking time percentages on highlight depth and an over-all depth.

The sinking time percentages are here

---

*We think this phenomenon can be fully accounted for by Merle Likins' "amount of energy entering the photochemical reaction" thesis in his "A Study of Variables Encountered in Producing the Gravure Surface," G.T.A. Bulletin (Vol. XV, No. 3) September 1964.

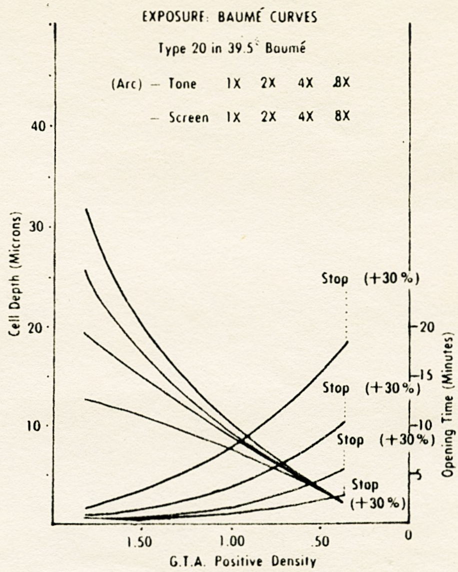

Fig. 13

12½, 25, 50, and 100 per cent.

It can be seen that, if we wish a 5-micron highlight, we should sink for about 60 per cent of the time it takes the highlight to open, 10.5 minutes, and stop the etch at 16.8 minutes.

If the solids are too deep, select either a lower Baumé or a shortened exposure (see Exposure/Baumé curves).

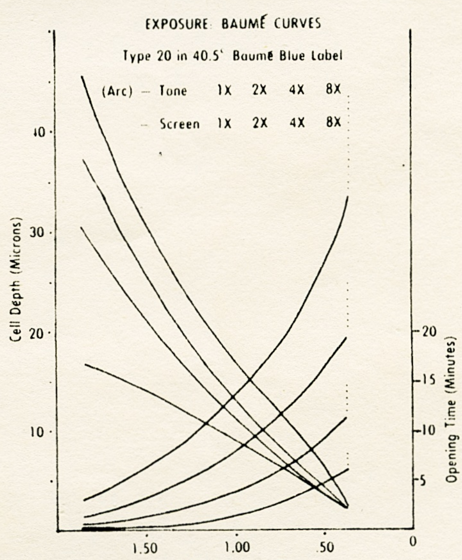

Fig. 14

(150-line 2½:1 Levey master; 41.0° Hunt's Blue Label).

Thirty-micron cells are shown in Figure 20.

SINGLE-ACID HIGHLIGHT CELLS
Two Microns Deep

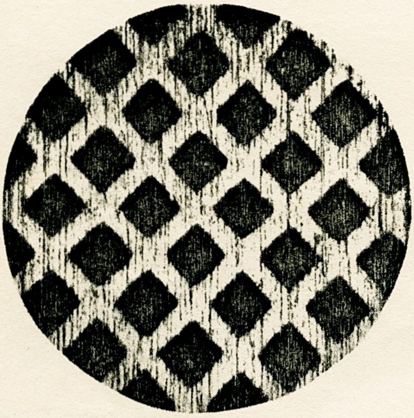

Fig. 18

SINGLE-ACID SHADOW CELLS
60 Microns Deep

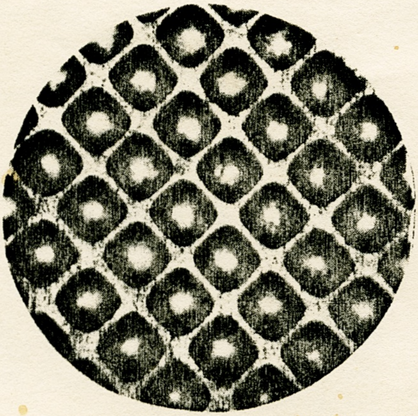

Fig. 19

SINGLE-ACID SHADOW CELLS
30 Microns Deep

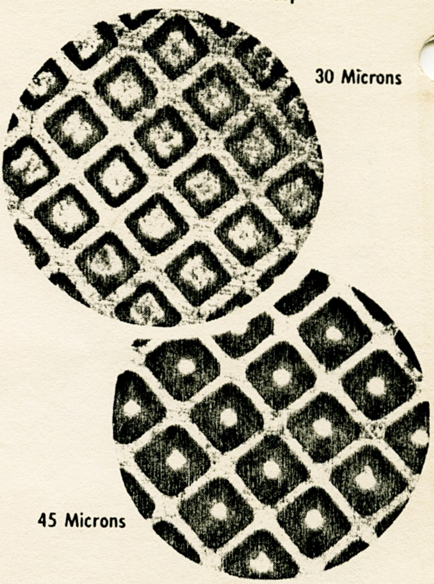

Fig. 20

Points for Control

HERE is a list of points for control, in descending order of importance:

1. *Effective printing densities* for positive highlights (G.T.A. .35) must match or be adjusted when exposing carbon tissues.
2. Temperature of cylinder and iron must repeat.
3. Iron Baumé must repeat ±1/10° Baumé.
4. Carbon tissue exposures must be repeatable in terms of actinic intensity × time.
5. Dark effect and continuing action must receive attention.
6. Ambient temperatures and relative humidity should be held near 70 degrees Fahrenheit and 60 per cent relative humidity.

Acknowledgments

I THANK my many friends in the rotogravure industry who have listened so patiently, answered questions so freely, and who have risked plates and cylinders testing and verifying these notions.