6-1-1979

A study of the effect of coating variations on tone reproduction in the Association Products Plate

Mark Woodhouse

A STUDY OF THE EFFECT OF COATING VARIATIONS ON TONE REPRODUCTION IN THE ASSOCIATION PRODUCTS PLATE

by

Mark Woodhouse

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Printing in the College of Graphic Arts and Photography of the Rochester Institute of Technology

June, 1979

Thesis advisor: Dr. Julius Silver

School of Printing
Rochester Institute of Technology
Rochester, New York

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to Certify that the Master's Thesis of

Mark Woodhouse

with a major in printing technology has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science degree at the convocation of

June, 1979

Thesis Committee: Julius Silver
Thesis Advisor

Julius Silver
Graduate Advisor

Mark Guldin
Director

ACKNOWLEDGEMENTS

I would like to thank Dr. Julius Silver for his time and patience, as well as Professors Dan Levine and Bekir Arpag of the School of Printing for their helpful advice and the use of their laboratory facilities and my wife Diane whose assistance in helping me achieve this goal is immeasurable.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The halftone process is so much a part of printing today that it is often hard for printers to conceive of the notion of reproducing an image without a screen. Before the idea of breaking up an image into small dots came along however, printing was being done with lithographic methods which produced excellent results and the main concern of the theorist and technician was how to produce a more consistent, higher-quality, continuous tone image. Perhaps it is unfortunate that the advent of the halftone process distracted thought from this area to such a large degree, since it wasn't until the early 1950's, a century after the first photo-lithographic prints were made with bitumen on stone that interest became centered once again on the possibilities of creating continuous tone images using conventional commercial equipment.

This revived interest in "screenless" methods of reproduction gave rise to many processes which employed concentional offset lithographic equipment to produce continuous tone images. While some variation was present in the approach of each of these processes, their fundamental principles were closely aligned with conventional lithography and it was eventually hypothesized and generally

accepted that the mechanism of image formation in these plates had to do with the grain structure of the substrate being used. While excellent results were achievable with these plates, they exhibited a lack of consistency and a touchiness in the area of exposure which made them unsuitable for adoption in commercial use on more than a limited basis.

In 1969 the Association Products Plate was introduced. This plate was unusual in that it seemed to be based in principle more on the collotype process than on conventional lithography; that is, it depended more fully on the light sensitive material being used than on the substrate. This plate too, exhibited lack of consistency and exposure problems which limited its adoption. Unlike the so called "random dot" processes mentioned above, the image forming mechanism of the Association Products Plate has not been satisfactorily defined.

In choosing to study the Association Products Plate from the standpoint of coating variations it was hoped to arrive at a demonstrable relationship between the coatings and subsequent tone reproduction, such that, as the coatings moved from the influence of the plate grain, tone reproduction should exhibit greater consistency and predictability. This, it was hoped, would establish the coatings themselves as the primary imaging agents, pointing the way to further study. The results did not support this contention.

CHAPTER I

INTRODUCTION

Credit for the concept which gave birth to further developments in the area of screenless printing generally goes to Nicephore Niepce who created a permanent photograph using bitumen developed in oil of lavender on glass or litho stone. The print was made by a transfer method.[1]

Lemercier followed Niepce's methods and using a grained stone created a series of true lithographic prints. Alphonse Poitevin substituted bichromate gelatin on stone for the bitumen and produced very satisfactory images.

> Between 1841 and 1860 several workers experimented with mixtures of bichromate with gelatin, glue and albumin as light sensitive coatings on paper and lithographic stones. Their work laid the basis for gravure printing, photo-engraving and photolithography. Exactly what each invented and when it is hard to determine since they kept their discoveries secret and sometimes didn't disclose them until several years later. Poitevin and Fox Talbot are generally credited with producing photolithographic images on stone using bichromated gelatin and glue in 1855. Lemercier, who worked with Poitevin is thought to have originated the well known bichromated albumin process. James and Osborne produced photolithographic transfers about 1859. They coated paper with bichromated gelatin and glue, made contact prints from negatives, inked the exposed coating and developed the prints in water.[2]

This phase in the development of printing is somewhat

confused, but it can be seen that it was during this period that the foundations for photolithographic printing were laid and the potentialities of screenless printing were first realized. At the same time experimental work was being done with the idea of screening a print, starting with the work of Fox Talbot in 1852 and leading to glass halftone screens which reached a peak of development in the work of Max Levy in 1896.[3]

The greater predictability and reliability of the half-tone process made it a desirable method and it is not surprising that the only process that survived as a screenless process was Poitevin's collotype. Particularly in the area of art reproduction, the quality of tone, detail and hue reproduction which collotype offers is virtually unattainable by any other process, and for that reason it is still in use today. Unfortunately collotype is possessed of certain inherent deficiencies, such as tedium in the area of exposure and camera work, unpredictability through a run and a short run capability that make it impractical for all but certain esoteric jobs. The fact that such an unwieldy process has survived at all serves as some testament to the attractive nature of screenless printing.

What caused a revival of interest in screenless processes in this century was the need of the Army to reproduce aerial photographs and topographical maps with a degree

of resolution not satisfactorily obtainable with halftone methods. Concurrent with this need came the introduction of positive diazos and photopolymers.

> Not long after World War II, when positive diazos were imported to the U.S. from Germany, several researchers noticed the long scale that these coatings could produce and work was started by the Army Map Service, GATF, and several commercial plants using ENCO, Silverlith and Harris positive plates among others. The shop which I have managed since 1942 was continuously required to reproduce aerial photographs and other intelligence pictures calling for great detail. It used all kinds of continuous tone methods: gelatin, photopolymers, and positive diazos.[4]

Many screenless processes arose around the middle of the century due to this renewed interest. Aquatone and its offshoot Optak were reasonably successful processes based on the collotype principle, but in order to achieve consistent results and longer runs it was necessary to incorporate a very fine line screen (400 lines) into the process. A number of processes developed after Sumner Williams' introduction of a positive working diazo plate in the early 1960's. Stone Tone, Progressive Color's Spectaprint, Alitho's Conkrome, Case Hoyt's Random Grain and Pulman's Finetone all appeared, having in common a random dot pattern created by the grain of the plate in conjunction with the light sensitive coating. Good results have been achieved with these plates, but generally complaints of inconsistency during a run and narrow exposure latitude are heard. None of these processes achieved widespread

acceptance.

In the late 1960's Union Carbide and Dr. Julius Silver introduced the Association Products Plate. Association products is the name given to a group of polymers which combine with each other in a manner other than chemical bonding and the polymers in the Association Products plate coating belong to this group. Negative working and single phase, this plate seemed to rely, in theory, less on the random graining of the plate and more on some as yet unidentified mechanism. Not much in the way of research and development beyond initial testing was done with this plate, nor have the random dot processes fared particularly well. Occasionally something is heard from Case Hoyt regarding commercial use of a random dot process and most recently, Pulman's "Fine Tone" process using Howson Algraphy Alympic Gold Plates was used to print the 1977 Photography Yearbook in England. Use of these plates is usually followed by a statement to the effect that general commercial availability is to result pending development of further controls. It is significant that Pulman's found it worthwhile to explore the possibility of screenless lithography in a long run situation. It is precisely in this area, fine photographic reproduction, as well as in the area of fine art reproduction that the possibilities of screenless printing are most intriguing and most commercially viable.

The problem involved in the study of screenless processes arises from the wholly theoretical nature of the body of knowledge surrounding the basic mechanics of their imaging systems. Certain explanations are taken as true in certain situations, but in every case these explanations are highly speculative.

In choosing to study the Association Products Plate it is hoped that a greater insight into the mechanics of image formation can be gained. Since this plate is quite different from the positive working, random dot plates, and since no theory for its behavior has been as satisfactorily put forth as have the theories for those plates it provides a unique medium for research, being unhampered by too many pre-conceived and potentially limiting ideas. For this reason a study of its workings can provide valuable information which relates to the behavior of all printing plates and processes. We are at a point in time in which the limitations of the halftone process are becoming more evident and the thrust is toward methods such as electrostatic and ink jet printing which can eliminate costly, tedious and image altering extra steps, including plates themselves. Screenless lithography can be a part of this forward thrust and can, if pursued, yield invaluable data regarding the interrelation of elements in imaging systems.

FOOTNOTES FOR CHAPTER I

[1] R. J. Lefebvre, "Continuous Tone Lithography," *Penrose Annual, The Process Yearbook*, Vol. 60 (1967), pp. 246-250.

[2] Charles W. Gamble, *Modern Illustration Processes* (London: Pitman and Sons, 1950), pp. 186-187.

[3] *Ibid.*

[4] Lefebvre, *loc. cit.*

CHAPTER II

THEORETICAL BASIS AND HYPOTHESIS

Screenless Lithography: Pro and Con

In order to understand the appeal of screenless lithography it is necessary to examine its distinguishing characteristics and the advantages it displays in certain applications as opposed to the conventional halftone method. Perhaps its most noteworthy characteristic has to do with resolution. In a halftone system the image is broken up into a network of dots and detail is necessarily lost to some degree. The degree of detail loss is less as the screen ruling becomes finer. In the screenless processes, while there is a visible random pattern created in many cases, it is comparable in detail to a very, very fine screen, often as fine as 1200 lines.[5] (For the Sumner Williams positive working plate.) This makes it especially attractive to serious photographers who are concerned with a high fidelity reproduction of their work, publishers and anyone for whom a high degree of detail reproduction is important.

Another positive point is that screenless processes are not beset with the problem of Moire patterns since

there is no screen to create the pattern. Also, since there is no screen the phenomenon of mid-tone jump cannot occur. This is a condition in which a radical change in tonal values occurs at the point at which the corners of the dots join to form the fifty percent dot. These features, as well as the fact that manipulation of screen angles and dot values becomes unnecessary, simplifies the mechanics of color separation.

Finally, from a purely mechanical standpoint, a screenless process offers the advantage of fewer steps and materials than a halftone system and the inclusion of one less image distorting or altering medium, namely the screen, between the original and the reproduction.

What has kept the screenless processes from becoming widely accepted on any large scale is the fact that they possess certain disadvantages that at this point outweigh their good points. Chief among the problems is inconsistency. Whether collotype, diazo or photopolymer, the complaint is always heard that the plates are hard to control during the course of a run, giving wide tonal variations and exhibiting a predictability far short of halftones run under identical conditions.

Another problem is the precision required in the negative and plate making areas. Exposures are critical as might be expected when dealing with a medium with such a high degree of resolution. Density ranges are quite short

and camera work must be precise to allow the correct compression of tones. This detracts somewhat from the advantage screenless offers in eliminating extra handling involved in screening.

Also connected to the resolving characteristics of these plates are register problems which occur in process work. Slight deviations are more noticeable than in halftone work with the same subject.[6] .

Obviously a greater knowledge of the workings and characteristics of these processes is needed before they are feasible as full alternatives to the halftone system.

Theories of Imaging Systems

In order to understand screenless lithography more completely, it is necessary to explore what is known about the workings of the various screenless processes. Basically they can be seen to depend to one degree or another on one of two mechanisms.

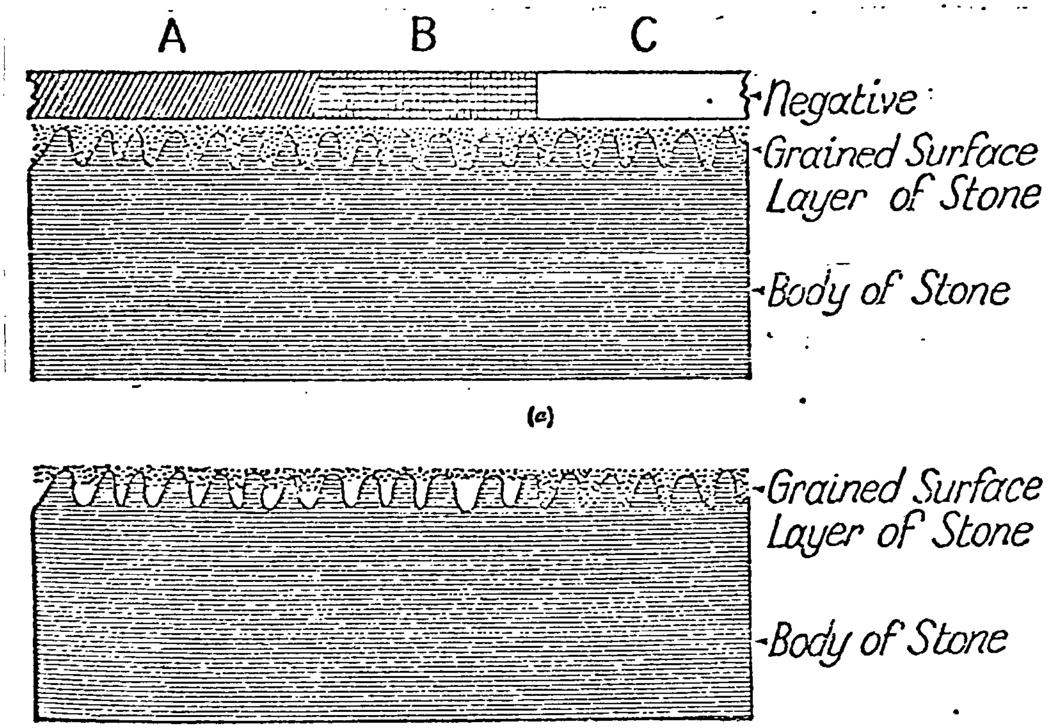
The first type depends for its image formation on the grain of the surface to which the light sensitive material has been applied. In its most fundamental form this particular mechanism is exemplified by a non-photographic process, conventional lithography.

> It has already been stated in connection with lithography that a line drawn upon a grained surface of the stone is not continuous, for the tops of the pyramids, the upstanding "grains" alone take the lithographer's chalk; but by varying the pressure the amount deposited varies.[7]

In related photolithographic methods varying pressure is replaced by varying degrees of light which reach the printing surface during exposure. This is the mechanism at work in creating pictures by means of bitumen on grained stone.

A light sensitive coating is applied to a grained surface and exposed under a continuous tone negative as seen in Figure 1. A represents the mid-tone, C the most transparent and B the most opaque region of the negative. On exposure to light for a given period of time, the greatest amount of light will have passed through C, less through A and still less through B. This means that the most bitumen will have been changed under area C, less under A and the least under B. In development the unchanged areas dissolve away leaving the insoluble, changed bitumen behind. The less exposed areas come away more readily, the more fully changed coating adheres to the grained surface creating a larger ink receptive area and the necessary tonal differentiation is achieved.

The effect here then is similar to that of the halftone in that variable ink receptive areas are created, grouped by the action of light, the difference being that, since the areas depend on the grain of the plate substrate, the groupings are much less regular and much finer than with a halftone screen. A similar mechanism was recognized by



(b)

(a) BEFORE EXPOSURE. SECTION OF GRAINED STONE BEARING FILM OF SENSITIVE BITUMEN (DOTTED PORTION) WITH A THREE-TONE NEGATIVE
(b) THE STONE AFTER EXPOSURE AND DEVELOPMENT. THE DIFFERENCE IN THE DOTTED PORTION REPRESENTS THE DIFFERENCE IN THE AMOUNT OF BITUMEN MADE INSOLUBLE

Figure 1[8]

Mechanism of Bitumen on Grained Stone

Irving Pobbaravsky and Milton Pearson in their study of image mechanisms in screenless lithography. They concentrated on positive working, diazo coated plates and their conclusion was that like conventional lithography and bitumen on grained stone, the creation of the image was a function of the grain of the plate.

> The ability of the plate to produce ink receptive spots varying in area is due to the point by point sensitivity distribution across the surface of the plate. This sensitivity distribution is in turn due to the coating thickness distribution formed by the peak and valley topography of the grained aluminum plate.[9]

This method of image formation has been the basis of many of the screenless processes used today and the explanations outlined here have been generally accepted as accurate appraisals of the mechanisms at work. This theory also offers an explanation as to why most screenless systems perform best as positive working systems. As can be seen by Figures 2 and 3, a negative working system leaves oleophilic areas only on the peaks of the grain where they are easily worn away while a positive working system leaves oleophilic areas deposited in valleys where they are much more stable and free from the effects of abrasion.

The second method of achieving continuous tone reproduction has to do with creating areas which selectively accept varying thicknesses of ink.

> Under certain conditions an exposed bichromated gelatin film will take on a crinkled surface and the crinkle will vary with the intensity of the tone. Certain parts will rise and others fall... the ink bearing area will vary throughout the tones and the necessary condition will be fulfilled.[10]

This is the basis of image formation in the collotype process according to popular concensus, the gelatin coating changing physically into a network or "reticulation" of variable ink receptive areas. This is an area of much

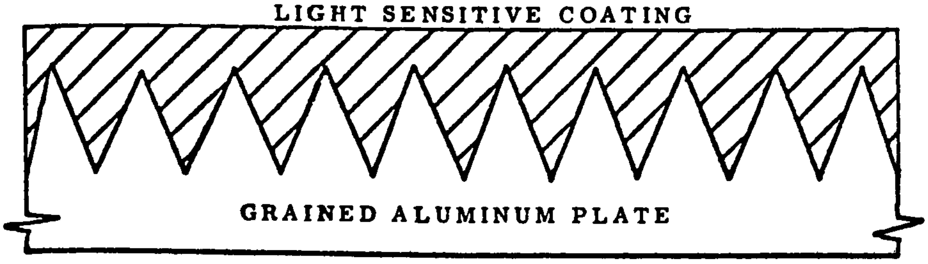


Figure 4c. Grained aluminum plate with light sensitive coating.

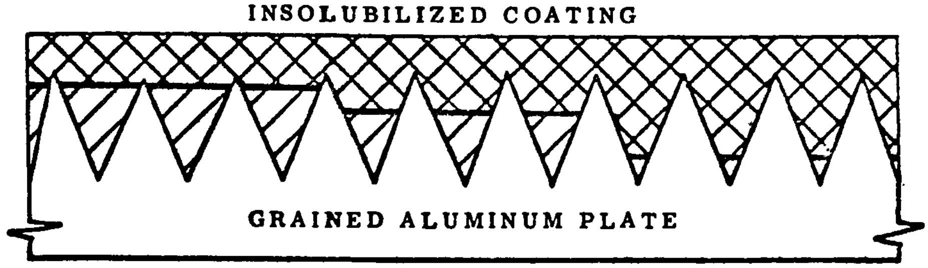


Figure 4d. Each third of the plate has been given an increasing amount of exposure starting from the left. Since this is a negative working coating, increasing exposure causes the coating to be insolubilized at deeper and deeper levels. Insolubilized coating is shown by crosshatching. Since the right hand side of the plate has received the most exposure, it shows the greatest depth of insolubilized coating. The coating in the grain valleys has been unaffected by exposure and is therefore soluble in the processing solutions.

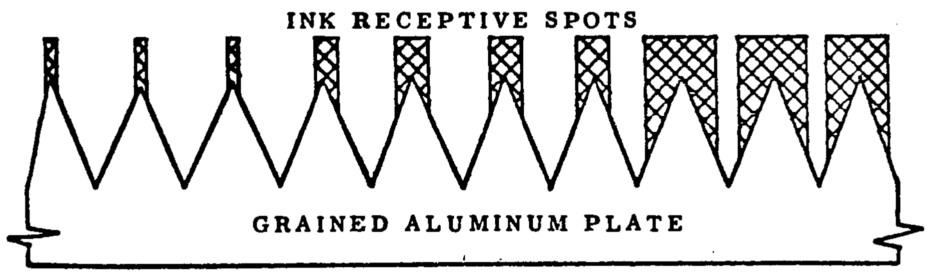


Figure 4e. This is the plate after processing. Only the insolubilized coating that has been anchored to the aluminum surface will remain after processing. This anchoring process will occur most quickly at the tops of the peaks where the coating is thinnest. Therefore a small amount of plate exposure will produce insolubilized coating on the peaks of the plate grain. As exposure is increased, anchoring takes place at deeper levels therby increasing the area of the insolubilized coating at the peak. Since this coating is ink receptive, it will print a spot of ink; the size of this spot is related to the amount of plate exposure and the slope of the plate grain.

Figure 2[11]

Pobbaravsky and Pearson's Mechanism for Negative Working Grained Plates

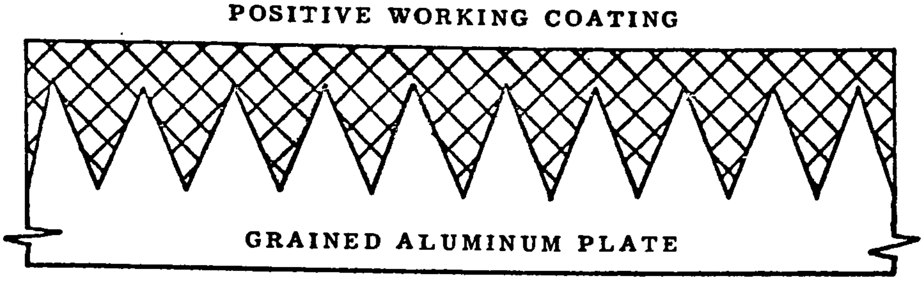


Figure 5a. This is a positive working coating on a grained aluminum plate. Before exposure this coating is insoluble in the processing solutions.

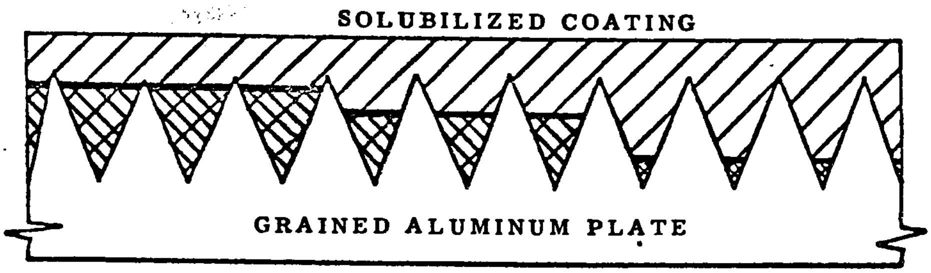


Figure 5b. Each third of the plate has been given an increasing amount of exposure starting from the left. Since this is a positive working coating, increasing exposure causes coating to be made soluble at deeper and deeper levels. The coating in the valleys (crosshatching) that has been unaffected by exposure is still insoluble in the processing solution. Since the right hand side of the plate has received the most exposure, it shows the greatest depth of solubilized coating.

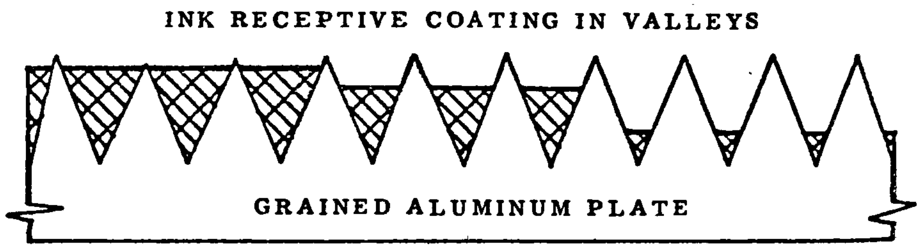


Figure 5c. This is the plate after processing. Coating solubilized by exposure has been removed in processing. The coating remaining after processing is ink receptive and will print spots of ink roughly comparable with those on the plate. Contrary to the negative working plate, printing takes place from the valleys in a positive plate. Furthermore, the greatest exposure produces the smallest ink receptive areas on the plate.

Figure 3[12]

Pobbaravsky and Pearson's Mechanism
for Positive Working Grained Plates

speculation but little concrete data. The reticulation effect is referred to as "graining" in many places and is thus aligned somewhat with the halftone or random dot processes. P. C. Smethurst has offered the most complete study of the subject although still far from conclusive. He dwells at length on the reticulation phenomenon and has devised a means of measuring the thickness of the gelatin layer after which the "average width of reticulation from valley to valley is found by use of a projection microscope and a count of the reticulations over a standard length in the projected plane."[13] While this is useful in determining a relationship between reticulation and tone reproduction, what is left unresolved is the question of the primacy of reticulation as the imaging agent. Agreement on collotype plates goes only so far as to say that reticulation is necessary for <u>stability</u> in printing, not for the continuous tone effect itself.

> Ease of Printing demands the formation of a well defined reticulation, though its absence does not mean the plate cannot be printed from - far from it; nor does this mean the grain must be coarse.[14]

While reticulation provides an answer which easily conforms to common conceptions of tone reproducing mechanisms, it does not seem to tell the whole story in this case. There appears to be some unknown mechanism at work which causes a variable ink receptivity and a more truly continuous tone effect.

In the Association Products Plate a similar mechanism seems to be at work. The behavior of the plate seems to point to a variable ink receptivity and a surface coating change which links it more closely to collotype than to any other process. This is partly evidenced by the fact that two phase, random dot plates work well only as positive working plates as we have seen, while the Association Products Plate works quite well as a negative working plate, implying that the grain is of secondary importance in image formation. No fully satisfactory theory has been put forth, however, as explanation for the behavior of this plate.

Fundamentals of the Association Products Plate

The Association Products Plate, simply explained, consists of a coating of poly (ethylene oxide) and phenolic resin on an aluminum substrate. Upon exposure to ultraviolet light this coating can be made to change from hydrophilic to oleophilic.

> Association Products - very often possess properties which are peculiar to the polymer combinations and not distinct in the individual polymers. When such Association Products are photosensitive per se or capable of becoming photosensitive by means of a photo-initiator then we can produce materials of use in printing applications.[15]

This provides a fundamental explanation for the working of the plate. As exposure increases, so too does ink receptivity. What, however, is at work to cause this receptivity

to vary from point to point upon exposure to a continuous tone negative in so selective a manner as to be able to render a continuous tone print? At the time of the creation of the plate a theory was offered by Dr. J. L. Silver to the effect that the coating was being hardened in proportion to the amount of light it received in such a sensitive and selective way that water was being accepted to a greater degree in the less exposed areas and thus less ink was received in those areas. Water and ink were therefore being accepted and rejected in varying degrees throughout the tonal values and this subtle variation from point to point accounted for the observable continuous tone effect.[16]

This explanation favors variable ink receptivity as the dominant mechanism. It is interesting to note here that in the initial testing of the plate, done by Berkowitz Press it was stated that:

> Furthermore, they did not have a great tendency to set off in the picture areas since tones carried a much thinner film of ink. Halftone systems carry the same thickness of ink film in all tonal values.[17]

This also implies that variable ink film thickness is a characteristic of the Association Products Plate although no supportive results or evidence are offered. If variable ink film thickness does play a major role in the process then precisely what is at work to cause this variation? In earlier work by Charles Martin it was hypothesized that the variation was caused by water emulsified in the ink to

different degrees creating a varying transfer of ink. He concluded that the degree of emulsification present was not sufficient to produce the gradation of tone and density exhibited by the plate.

There are theoretically several ways in which the image can be formed, each of which individually or in combination with another, might be the primary factor. A mechanism similar to the random dot process could be at work, forming ink receptive areas of varying size. This type of effect has been hypothesized at various times as depending on the grain of the plate, the grain structure of the negative used to expose the plate, the coarseness of the ink pigment or the structure of the plate coatings themselves. This type of mechanism could be at work independently or in combination with a variable ink receptivity.

The problem involved in studying the Association Products Plate has to do with recognizing the degree of contribution of different factors to tone reproduction. While we are able to say in general what the fundamental principles of the plate are, definition of its uniquely sensitive behavior remains highly speculative.

In the study which set forth the peak and valley theory for image formation in the positive working diazo plates Irving Pobbaravsky and Milton Pearson eliminated grain of the negative as well as ink structure as factors in image

formation for those plates. They determined that the continuous tone effect could be achieved without the use of a grainy negative and also that the image appeared as continuous tone before the plate was inked. While neither of these has been eliminated completely as a factor in the image mechanism of the Association Products Plate, it seems that more profitable exploration would lie in the direction of the coatings themselves.

In the random dot processes the grain of the plate, while forming the image, could also give rise to much of the inherent inconsistency of the plate, due to wear, grain variation from plate to plate and varying acceptance of coatings. The Association Products Plate has been seen to work best on Sumner Williams ST aluminum, a fact which supports the notion that the grain of the substrate plays some role in the performance of the plate. What needs to be determined is whether we are dealing with a mechanism dependent solely on the behavior of the coatings themselves or with a mechanism dependent for its efficacy on a combination of factors. Essential to this approach is an analysis of the behavior of the plate under varying coating conditions.

Toward this end, this study has attempted to show the effect of coating variation on the printing characteristics of the Association Products Plate. It was hoped to establish the autonomy of the coatings themselves as the imaging

agents.

Hypothesis

As prime coating concentrations are increased and the plate moves further from the influence of the grain, a greater consistency of tone reproduction should result.

FOOTNOTES FOR CHAPTER II

[5]LeFebvre, *loc. cit.*

[6]Stuart P. Berkowitz, *Continuous Tone Plate Analysis*, Report of Berkowitz Press, Elizabeth, New Jersey, April, 1968 (Elizabeth, New Jersey: Berkowitz Press, 1968), p. 6.

[7]Gamble, *loc. cit.*

[8]*Ibid.*, pp. 243-244.

[9]Irving Pobbaravsky and Milton Pearson, "Study of Screenless Lithography," *TAGA Proceedings* (1967), pp. 249-262.

[10]Gamble, *loc. cit.*

[11]Pobbaravsky and Pearson, *loc. cit.*

[12]*Ibid.*

[13]P. C. Smethurst, "The Technical Background of the Collotype Process," *The Photographic Journal* 92B (July/August, 1952): 117.

[14]Gamble, *op. cit.*, p. 213.

[15]J. L. Silver, "Photosensitive Association Products," *TAGA Proceedings* (1969), p. 141.

[16]J. L. Silver, "Printing Plate Compositions," Canadian Patent 749,895 (1967).

[17]Berkowitz, *loc. cit.*

CHAPTER III

METHODOLOGY

Plate Preparation and Materials

In order to study the Association Products Plate it was necessary to make the coating solution and to coat and sensitize the plates in the laboratory using a formulation and procedures provided by Dr. J. L. Silver. The original Association Products Plate used Sumner Williams ST aluminum as the substrate. This material is no longer available so a common brush grained aluminum was substituted.

To test the basic hypothesis it was necessary to coat each set of plates with a different thickness of coating. While the actual thickness of each coating was not measured, coatings were prepared in such a manner as to create a thickness variation from batch to batch. "By increasing the solids, the viscosity of the solution increases proportionally and thicker layers are produced."[18] This method of approach is further verified by Herbert Leedy who states that "an increase in viscosity will retard the flow rate of the solution and result in a proportional increase in coating thickness."[17] Thus, by preparing the coating solutions

at various viscosities varied thicknesses of coating were produced. To keep the coatings proportionally constant it was necessary to vary only the viscosity, keeping all other factors constant. Viscosity variation was achieved by increasing the amount of solvent in the formulations. The amount of solvent added differed from batch to batch of coating due to the nature of the blending method used, so that solvent was added and viscosity readings were taken for each batch until the desired viscosity was achieved.

Coatings were prepared in as consistent a fashion as possible, using a Mettler balance for weighing in proper proportion. All ingredients were blended for forty minutes in a Waring laboratory blender and allowed to cool at which time viscosity readings were taken. The solution was then diluted according to formula, blended, cooled and checked for final viscosity. A Brookfield rotational viscometer was used to obtain viscosity readings. Approximately 50 ml. of coating solution was used for each plate prepared. Coatings were applied in a standard heated whirler, allowed to dry on the whirler then cured at 160°C in a laboratory oven. The Association Products Plate is often made with a prime coating composed of the basic polymeric elements of the top coating formulation. The purpose of the prime

coating is to insure the adherence of the top coating to the substrate. These prime coatings were prepared using various concentrations of phenolic resin in DMF, whirled on in a similar fashion and cured at 160^{o}C.

Sensitizing was done with a ½% solution of Fairmont DE-40 in Acetone. Plate exposure tests were performed using a Stouffer 21 step gray scale in a NuArc Mercury Vapor printer with integrator to assure constant exposures from test to test. Presswork was done on an ATF Chief 15 press using standard ink and fountain solution.

FOOTNOTES FOR CHAPTER III

[18]J. Kosar, Light Sensitive Systems (New York: John Wiley and Sons, Inc., 1965), p. 80.

[19]Herbert Leedy, "Coating Thickness and Its Importance in Lithographic Platemaking and Performance," TAGA Proceedings (1949), p. 35.

CHAPTER IV

RESULTS

Testing of Plates Without Prime Coating

The main purpose of the experiment was to test the effect of coating variation on the performance of the plates. In order to separate the printing characteristics from the characteristics of the plate grain and to arrive at some basic understanding of the behavior of the coatings themselves it was necessary to study a number of variables.

First of all, to provide a basis for comparison it was thought best to begin by preparing plates using no prime coating. This was done using coatings of various concentrations applied to plain brush grained aluminum. In order to conform to the basic hypothesis these plates would have to exhibit a negative effect in the area of tone reproduction at lower viscosities, creating an inconsistency which would diminish as the coatings became thicker and more independent as the imaging agents.

Several batches of plates were prepared at various viscosities and were exposed to a Stouffer scale as well as a masked photographic negative. In the case of short exposures no ink receptivity was evidenced. In those areas

in which receptivity was noted the coating began to come off the plate after a short run-in time on the press. Loss of coating in each case occurred before the plate would receive sufficient ink to reproduce an image. In the case of the lower viscosity, thinner coatings the coating was seen to come off in the developing bath. It was observed that an increase in exposure yielded a quicker, more complete coating loss such that in areas of relatively long exposure the plate would accept a thick, constant film of ink incapable of reproducing tones.

What was concluded from this data was that a solubilization reaction was occurring in which part of the coating was being solubilized on exposure and removed during development. Also, over a longer run-in period coating wear could be seen to take place over the whole surface of the plate. What can be concluded from that is that the prime coat, originally intended as an aid to coating adherence on deep grained ST aluminum, is necessary to adherence with the type of grain with which we were working.

In relation to the basic hypothesis, the findings of this part of the experiment tended to refute the notion that thicker coatings would be more consistent. Thicker coatings were neither more consistent nor more ink receptive as had been postulated. However, the appearance of a solubilization reaction still pointed to a greater consistency to be

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
1/4 unit	none	10 min.	none	none
1/2 unit	none	10 min.	none	none
3/4 unit	none	10 min.	none	none
1 unit	none	10 min.	none	none
1 1/4 units	none	10 min.	none	none
1 1/2 units	none	10 min.	none	none
1 3/4 units	none	10 min.	none	none
2 units	slight	10 min.	slight	none
6 units	heavy	10 min.	heavy	none
		BATCH 1		
viscosity	160 cps		prime coat	no
# of plates	2			

Table 1

Behavior of unprimed plate. Top coating viscosity 160 cps.

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
1/2 unit	none	10 min.	none	none
1 unit	none	10 min.	none	none
1 1/2 units	none	10 min.	none	none
2 units	slight	10 min.	none	none
2 1/2 units	slight	10 min.	none	none
3 units	slight	10 min.	none	none
3 1/2 units	slight	10 min.	none	none
4 units	slight	10 min.	none	none
5 units	heavy	10 min.	heavy	none
6 units	heavy	10 min.	heavy	none
7 units	heavy	10 min.	heavy	none
		BATCH 2		
viscosity	90 cps		prime coat	no
# of plates	2			

Table 2

Behavior of unprimed plate. Top coating viscosity 90 cps.

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
1 unit	slight-heavy	20 min.	heavy	none
1 1/2 units	slight-heavy	20 min.	heavy	none
1 3/4 units	slight-heavy	20 min.	heavy	none
2 units	slight-heavy	20 min.	heavy	none
3 units	slight-heavy	20 min.	heavy	none
4 units	slight-heavy	20 min.	heavy	none
5 units	slight-heavy	20 min.	heavy	none

BATCH 2

viscosity 90 cps — prime coat no

# of plates 2

Table 3

Behavior of unprimed plate. Top coating viscosity 90 cps. Extended run-in period.

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
1 unit	very slight	10 min.	very slight	slight
2 units	very slight	10 min.	very slight	slight
3 units	very slight	10 min.	very slight	slight
4 units	very slight	10 min.	very slight	slight
5 units	slight	10 min.	slight	slight
6 units	slight	10 min.	slight	slight
7 units	slight	10 min.	slight	slight
8 units	slight	10 min.	slight	slight
10 units	slight	10 min.	slight	slight

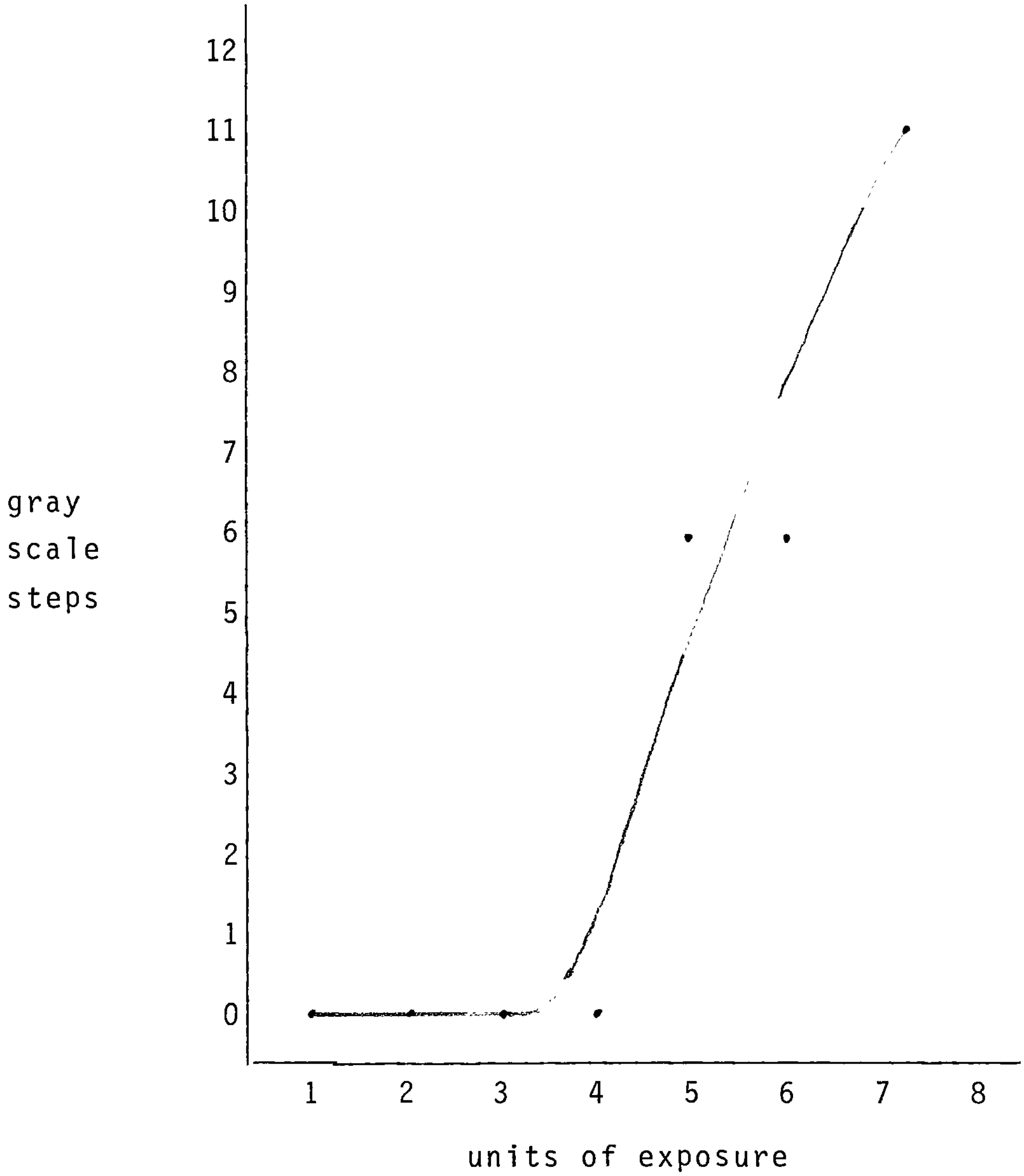
BATCH 3

viscosity 60 cps — prime coat no

# of plates 2

Table 4

Behavior of unprimed plate. Top coating viscosity 60 cps.



Vertical axis expresses the number of gray scale steps observed to exhibit a greater than 50% loss of coating. Number of plates observed-4.

Figure 4

Solubilization

achieved with use of a prime coating.

Solubilization

The apparent solubilization reaction was an unexpected phenomenon and in order to better document what appeared to be occurring data was distilled from the material at hand. Solubilization was figured by taking the average number of gray scale steps seen to exhibit a greater than 50% coating loss (by visual inspection) at a given exposure for a given coating concentration (90 cps) and a given development and run-in time. The conclusion was that longer exposures were yielding a higher degree of solubilization.

Prime Coat Ink Receptivity

The prime coating used in these tests was a mixture of phenolic resin and solvent, phenolic being the chief oleophilic component of the system. The main function of the prime coating is to provide greater adherence of the top coating to the aluminum substrate. With the discovery of the solubilization reaction the prime coating could be seen to have a relation to the imaging mechanism which is more direct than was previously supposed. If coating is being removed in proportion to exposure then the presence of a highly oleophilic prime coating underneath should cause an increase in ink receptivity proportional to the removal

of coating. This is in keeping with the basic hypothesis, since a higher concentration of prime coating should be more ink receptive and more removed from the influence of the plate grain.

To test the basic assumption here, which is that the prime coat, so composed, is highly ink receptive, plates were prepared at varying concentrations of prime coating, dampened and inked up on the bench using a standard developing ink. These plates were found to take ink quite readily and a visual comparison as well as a desitometric evaluation showed that a higher concentration of prime coating was taking ink more readily.

Prime Coat Variation

In order to support the basic hypothesis, plates coated with a higher concentration of prime coating would need to exhibit a greater consistency than plates coated with lower concentrations; that is, all other conditions remaining the same, a plate of higher concentration should show less gray scale drift and more stability over the course of a run. To test this a number of plates were prepared at various concentrations of prime coating, coated with an identical top coating and sensitized and exposed as before.

The results showed that, contrary to expectation, higher concentrations of prime coating were actually less

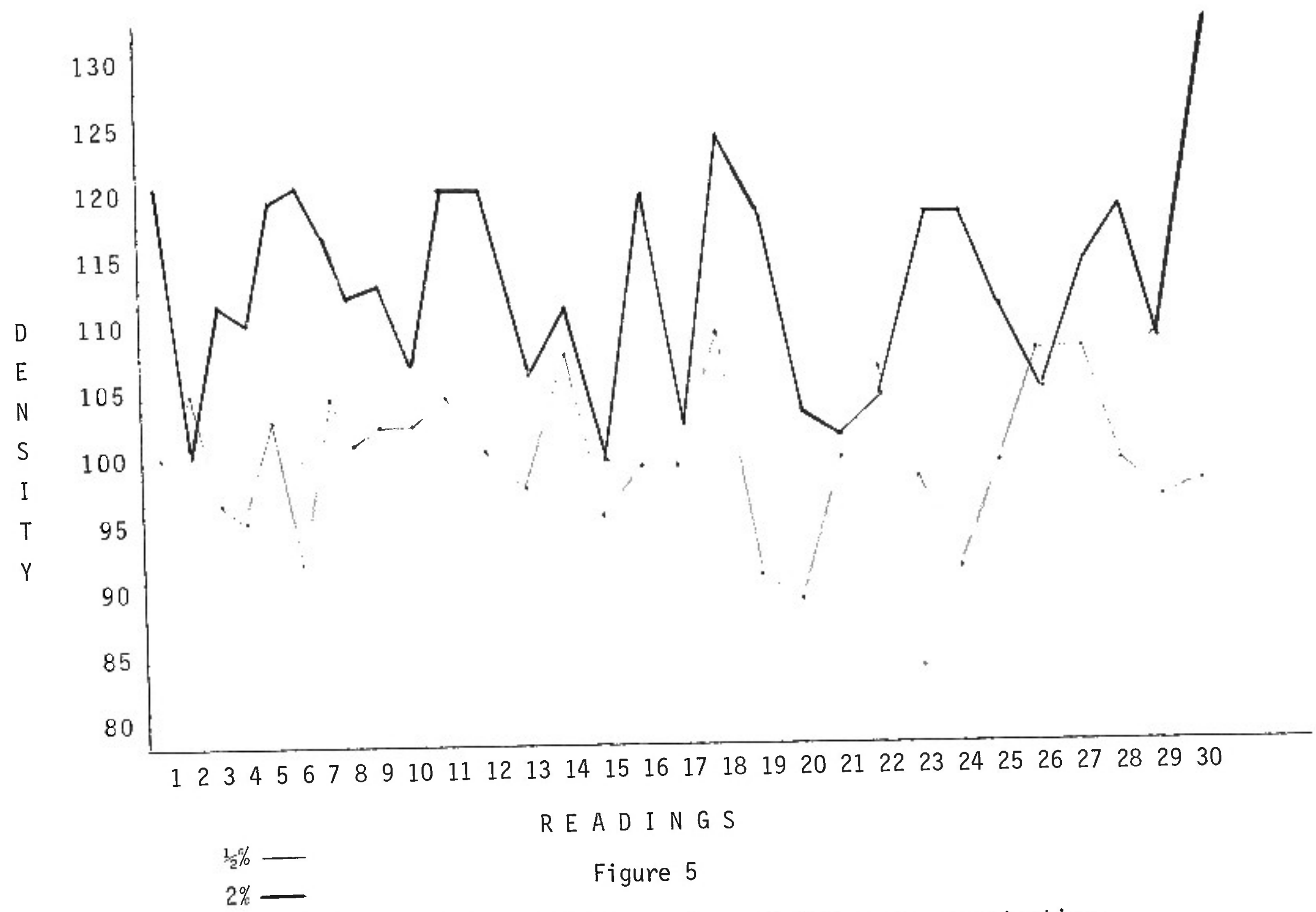


Figure 5

Relative ink receptivity of prime coatings of different concentration.

receptive to ink. At a concentration of 1% the plates became more ink receptive and showed some printability. Below that percentage coating wear again became evident and printed gray scales showed narrow tone differentiation, printing many solid steps.

It was concluded that the prime coating did increase the adherence of the top coating greatly, since at higher concentrations there was no visible evidence of coating loss regardless of exposure. The evidence indicated a refutation of the basic hypothesis since higher concentration thicker coatings were seen to perform repeatedly in a manner directly opposed to that hypothesized.

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
2 units	none	30 min.	none	none
4 units	none	30 min.	none	none
6 units	none	30 min.	none	none
8 units	none	30 min.	none	none
10 units	none	30 min.	none	none
12 units	none	30 min.	none	none
14 units	none	30 min.	none	none
16 units	none	30 min.	none	none
18 units	none	30 min.	none	none
20 units	none	30 min.	none	none
top coating viscosity 180 cps			prime coat yes	
# of plates 4			concentration 5% & 2%	

Table 5

Behavior of primed plates. Prime coating concentrations 5% and 2%.

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
2 units	none	30 min.	none	none
4 units	none	30 min.	none	none
6 units	none	30 min.	none	none
8 units	none	30 min.	none	none
10 units	none	30 min.	none	none
12 units	none	30 min.	none	none
14 units	slight	30 min.	slight	slight
16 units	slight	30 min.	none	slight
18 units	slight	30 min.	none	slight
20 units	slight	30 min.	none	slight
top coating viscosity 180 cps			prime coat yes	
# of plates 2			concentration 1%	

Table 6

Behavior of primed plates. Prime coating concentration 1%.

TIME	INKING	RUN-IN	COATING LOSS	PRINTABILITY
2 units	none	30 min.	none	none
4 units	slight	30 min.	none	slight
6 units	slight	30 min.	none	slight
8 units	slight	30 min.	none	slight
10 units	slight	30 min.	none	slight
12 units	heavy	30 min.	slight	slight
14 units	heavy	30 min.	slight	slight
16 units	heavy	30 min.	heavy	slight
18 units	heavy	30 min.	heavy	slight
20 units	heavy	30 min.	heavy	slight
top coating viscosity 180 cps			prime coat yes	
# of plates 2			concentration ½%	

Table 7

Behavior of primed plates. Prime coating concentration ½%.

Varying Top Coat

As a final test of the basic hypothesis and to yield further data on the relation of coatings to printability, plates primed at a 1% concentration were coated with top coatings of various concentration. Once again, the higher viscosity, thicker coatings showed no ink receptivity, the lower showed deterioration of coating while the medium viscosity showed the best receptivity without deterioration. In none of the plates was there evidence of sufficient receptivity for the production of a satisfactory image. It was concluded that the basic hypothesis is invalid. It was also concluded that the plate coatings cannot be reasonably considered independent imaging agents.

Exposure: (units)	1	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2 Plates 160 cps															
Inking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coating Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 Plates 120 cps															
Inking	0	0	0	0	0	0	0	s	s	s	s	s	s	s	s
Coating Loss	0	0	0	0	0	0	0	s	s	s	s	s	s	s	s
1 Plate 40 cps															
Inking	s	s	s	s	s	s	h	h	--	--	--	--	--	--	--
Coating Loss	s	s	s	s	s	s	h	h	--	--	--	--	--	--	--

0 = none

s = slight

h = heavy

Table 8

Behavior of primed plates. Top coating varied.

CHAPTER V

SUMMARY AND CONCLUSIONS

In reviewing the data collected from this series of experiments several interesting points came to light. Initially it was expected that the difference between batches of plates would be such that tone reproduction curves could be established yielding data as to the relative effect of coatings on plate performance. As it turned out only one set of plates performed sufficiently well on the press to produce a remotely measurable image, and even in this case the quality was minimal. For this reason the difference in performance from batch to batch was starkly visible if not conducive to subtle numerical analysis. So too, the effect of exposure and run-in was consistent and readily visible. All of this offered data on the relation of the coatings to each other and to the imaging characteristics of the plate in a manner different from that originally intended.

The significance of the data can best be seen by looking at the overall pattern of the plate behavior in relation to the basic hypothesis. The thrust of the original postulate was that the plate coatings could be

demonstrated to be independent imaging agents by systematic variation of the coatings. In every instance this was refuted by the evidence compiled. In the case of unprimed plates coating adhesion was too poor to allow continuous tone imaging and thicker coatings allowed no inking at all. In primed plates of varied prime and top coatings, adhesion was noticeably better but again no inking occurred at higher concentrations. The observation of solubilization offered a clue, but the solubilization reaction did not appear to be sensitive enough to allow the ink receptive prime coat to be revealed in a sufficiently selective manner to produce continuous tone images. Once again, higher concentration, thicker coatings were stubbornly non-receptive to ink.

In theory the plate substrate should make little difference to the performance of these plates.

> The plastic coating is baked onto grained aluminum since this carrier has the mechanical properties to which lithographers are accustomed. However, the substrate can be steel or any other material of suitable mechanical properties.[20]

In actual practice, the substitution of Fuller Brush Grained aluminum used in this study for the unavailable Sumner Williams deep grained ST aluminum used in the previous successful applications of this plate seems to have caused a radical difference in the behavior of the plate. While the substrate may not make a great deal of difference in

the application of this plate to conventional halftone printing, the mechanism for continuous tone printing appears to be more demanding.

What the evidence seems to indicate is that the aluminum substrate cannot be reasonably discounted as a factor in the imaging mechanism of this plate. Something unique to Sumner Williams ST aluminum seems to be the catalytic ingredient which makes the use and analysis of these plates easier and more commercially viable. While it can be argued that the plate coatings could be changed to accommodate a different grain or ideally, no grain at all, it remains an unavoidable conclusion that the particular coating formulation used in this study seems to depend in some way on the deep grain structure peculiar to the ST aluminum and the mechanism being observed is inextricable from this structure.

The importance of the grain is further evidenced in observing the solubilization reaction. As exposure increases and more coating is removed the plates begin to become more receptive to ink, until they reach a point at which too much coating has been removed and inking becomes erratic. This implies that a certain critical point is reached in which the combination of the grain and coating work in harmony to reproduce images.

Still unresolved is the question of whether we are looking at a phenomenon akin to the random dot effect, or

at a variable ink transfer caused by some unknown factor. In short, the mechanism remains undefined and appears to be either more complicated than a single explanation will allow; that is, a combination of effects is at work to create the continuous tone characteristics, or the mechanism is of a nature which has yet to be considered; that is, we are limiting ourselves by pre-conceived notions as to the workings of a continuous tone printing system.

FOOTNOTE FOR CHAPTER V

[20]Silver, "Photosensitive Association Products," p. 146.

CHAPTER VI

RECOMMENDATIONS FOR FURTHER WORK

This study indicates that the plate grain characteristics influence the performance and this influence appears to show up in adhesion of the coating.

It is recommended that the followed be investigated:

1. While Sumner William Corporation "ST" aluminum is no longer available, the specification should be obtained and similar metal be used for these plates.

2. Using the standard top coating solution, the effect of grain depth on performance should be studied.

3. Formulation variables for the top coat should be studied and correlated with performance while using one standard sub-coat formulation.

4. A key element is the degree of "cure" or heat induced cross-linking of the top coat. An experimental procedure for measuring this degree of cure should be developed.

BIBLIOGRAPHY

BIBLIOGRAPHY

Berkowitz, Stuart P. Continuous Tone Plate Analysis. Report of Berkowitz Press, Elizabeth, New Jersey, April 1968. Elizabeth, New Jersey: Berkowitz Press, 1968.

Gamble, Charles W. Modern Illustration Processes. London: Pitman and Sons, 1950.

"Improving on a 178 Year Old Invention," Printing Trades Journal, December 1976, p. 15.

Kosar, J. Light Sensitive Systems. New York: John Wiley and Sons, Inc., 1965, p. 80.

Leedy, Herbert. "Coating Thickness and its Importance in Lithographic Platemaking and Performance," TAGA Proceedings (1949), p. 35.

LeFebvre, R. J. "Continuous Tone Lithography," Penrose Annual, The Process Yearbook, Vol. 60 (1967), pp. 246-247.

Penrose Annual. (1976), pp. 21-25.

Pobbaravsky, Irving and Pearson, Milton. "Study of Screenless Lithography," TAGA Proceedings (1967), pp. 249-262.

Silver, J. L. "Photosensitive Association Products," TAGA Proceedings (1969), p. 141.

Silver, J. L. "Printing Plate Compositions," Canadian Patent 749,895 (1967).

Smethurst, P. C. "The Technical Background of the Collotype Process," The Photographic Journal (July/August 1952), pp. 115-123.

General References

Elyjiw, Zenon. "Screenless Lithography," GATF, Reports of Progress during 1965 (1966).

"How to Do Continuous Tone Lithography," Printing Production, December 1968, pp. 38-39, 74, 77.

Ikeda, Tomoake, Kumagai, Hiroji, and Masui, Kiyoshi, "Tone Reproduction in Screenless Lithography," Graphic Arts Japan, 1968-1969, pp. 41-45.

Lerner, Harry H. "Results of a Study on Offset Collotype," TAGA Proceedings (1954), pp. 26-32.

Materazzi, Albert R. "Screenless Printing," Graphic Arts Monthly, December 1974, pp. 76, 78-79.

"Screenless Litho System from Bletchley Printer," Printing World, October 15, 1976, p. 14.

"Screenless Lithography - A Commercial Possibility," British Printer, Vol. 89, No. 12, December 1976, p. 17.

Uhlig, F. "Screenless Offset Printing Process Using Presensitized Printing Plates," The Journal of Photographic Sciences (1970), pp. 4-7.