EMULSION INKS FOR SINGLE FLUID LITHOGRAPHY

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Abstract

Inks have been developed for single fluid lithography. Four process color emulsions have been successfully run on a prototype, positive feed, Keyless press without dampener. Emulsions of inks contained fountain solution or tap water, depending on the formulation. Criteria have been established for determining the necessary emulsion qualities for this printing process using rheometry and differential scanning calorimetry. Print quality is examined in single color and four color modes as functions of water volume and press speed, as well as comparison to conventional lithography.

Introduction

"Single fluid" (i.e. emulsion) lithography is an attractive concept which could lead to:

- Simplification of the lithographic process, including press and ancillary equipment (e.g. no dampening unit).
- Removal of fountain solution problems, including environmental concerns, if tap water can be used.
- Unique performance characteristics due to quicker press equilibration (e.g. reducing paper waste).

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The emulsion concept is not a new one; in fact, there are several examples of emulsion inks for lithography found from 1920-1940. [Holmes and Cameron (1922); Fitzgerald (1922); Mehl (1932); Rowell (1933); Clark and Pauer (1963); Bulloff (1974).] The key problem at that time and which is of ultimate concern for any single fluid approach:

The water requirements to maintain a clean non-image area must be accommodated by a single ink/water ratio of the printing emulsion. Thus, the ability of the emulsion to maintain clean printing at various image coverages (from low to high) is a formidable hurdle.

In addition to this critical problem, the early work was plagued by:

- Empirical and ill-defined emulsion requirements which made them inconsistent in performance.
- In some cases, plate treatments were required which greatly increased the complexity of the system.

More recently, attempts such as made at Milwaukee Journal to run emulsions via direct lithography, also enjoyed only limited success due, basically, to the stability problems. DeSanto et al. describe a recent single fluid composition but its press history is unclear.

Given the press design features as described in the previous paper which overcome some critical problems of the concept, the emulsion for this process must possess requirements not all necessarily associated with typical lithographic inks.

1. The emulsion must contain adequate amounts of aqueous phase to maintain clean printing at all coverages.
2. The emulsion must be able to handle distribution and transfer processes on

the roller train without premature separation and selectively break out at the point of maximum shear rate (i.e. at the plate).

3. The emulsion cannot be excessively stable to preclude sufficient release at the printing plate.

4. The rheology of the emulsion (at relatively large fractions of water) must be such to maintain the desired print properties (e.g. density requirements, solid lay, dot gain).

5. The unused emulsion (via scraper of return ink) must be able to have water content readjusted when necessary and possess the same properties as when initially formed.

The attempts to provide the above noted features to the ink also require new test methods and different approaches than examined for conventional lithography. It is clear that proper emulsion stability is the key for maintaining the single fluid lithographic process.

In this paper, the characterization of proper rheology and stability of emulsions for the Rockwell Positive Feed Keyless press design is described. Emulsions which had various quantities of aqueous phase (i.e. either fountain solution or tap water) have been prepared and successfully run on press. General criteria for successful formulation of single fluid inks are outlined. Four process colors were run and print quality assessed relative to conventional lithography.

Experimental Section

A. <u>Preparation of Emulsion</u>

All emulsions were formed on a weight basis from inks of conventional viscosity associated with injector type feed systems. They were prepared in a laboratory on a simple mixer. For press trial, a double Cowles type blade was used at approximately 1500 rpm.

B. Thermal Analysis

A DuPont Differential Scanning Calorimeter (Model 910) was used, with the following test conditions:

Heating Ramp	5°C/minute
Start Temperature	20°C
End Temperature	170°C
Sample Size	2.0 - 3.5mg

C. Flow/Creep Experiments

A Carri-Med CLS Rheometer was used in cone and plate mode with a 2°, 4 cm diameter cone. A linear stress ramp was carried out on the samples at 30°C for flow. Creep/Recovery was carried out at applied stress of 100 dynes/cm^2 for 2 minutes for each experiment.

Results

Rheological Comparison

From the formulation standpoint, the definition of "proper" emulsion stability was necessary in order to produce a set of process colors. Three conventional lithographic inks were available to assess at the beginning of this project:

1. Cyan A - ran successfully as a 35% emulsion of fountain solution (Flint V2020; Cond - 2000µmhos).

2. Cyan B - a different batch of A, for which the retention of 35% fountain solution within the ink was not possible over time.

3. Black (SF ROCK B1) - a poor running ink which did not clean up, even with 50% of fountain solution emulsified into the ink.

Cyan A and B were obtained from the same manufacturer at different times and purported to be the same product. These three inks did not show unusual neat ink properties and Cyan A and B were identical in almost all respects. As emulsions (see Figures 1A and B), they did show distinction in their relative stability. The black ink (Figure 2) showed large increases in yield and viscosity upon emulsification.

The initial interpretation of the emulsion flow behavior was that the stress at the plateau is related to the critical stress at which the emulsion breaks down. The higher the critical stress, the more stable the emulsion to shear. Cyan A shows a lower critical stress than B, but the relevance of this is unclear as the kinetic stability of the emulsions was manifested by the inability of B to hold water over time, rather than thermodynamic stability. The black ink represents a very high critical stress and probably suggests an emulsion was formed which was too stable for the process.

Using this limited information, a black formulation was prepared and after a successful run on press, a more detailed comparison was made to the failed ink. Figures 3A and B show the emulsion flow of the two inks as a function of weight percent of fountain solution. The formulation labeled SF SUN BLACK is distinct in that its critical shear stress is much lower and flow behavior is more in line with neat ink. SF ROCK B1 shows gross yield and viscosity changes and higher stress. The relative differences in emulsion behavior were also noted for creep behavior at 35 and 50% emulsions. Figures 4A and B show the differences in low shear behavior as water volume increases. The behavior of SF ROCK B1 shows less strain as the water level increases, indicating a more structured state and, thus, more stable emulsion. SF SUN BLACK shows a large increase in strain as the water level increases,

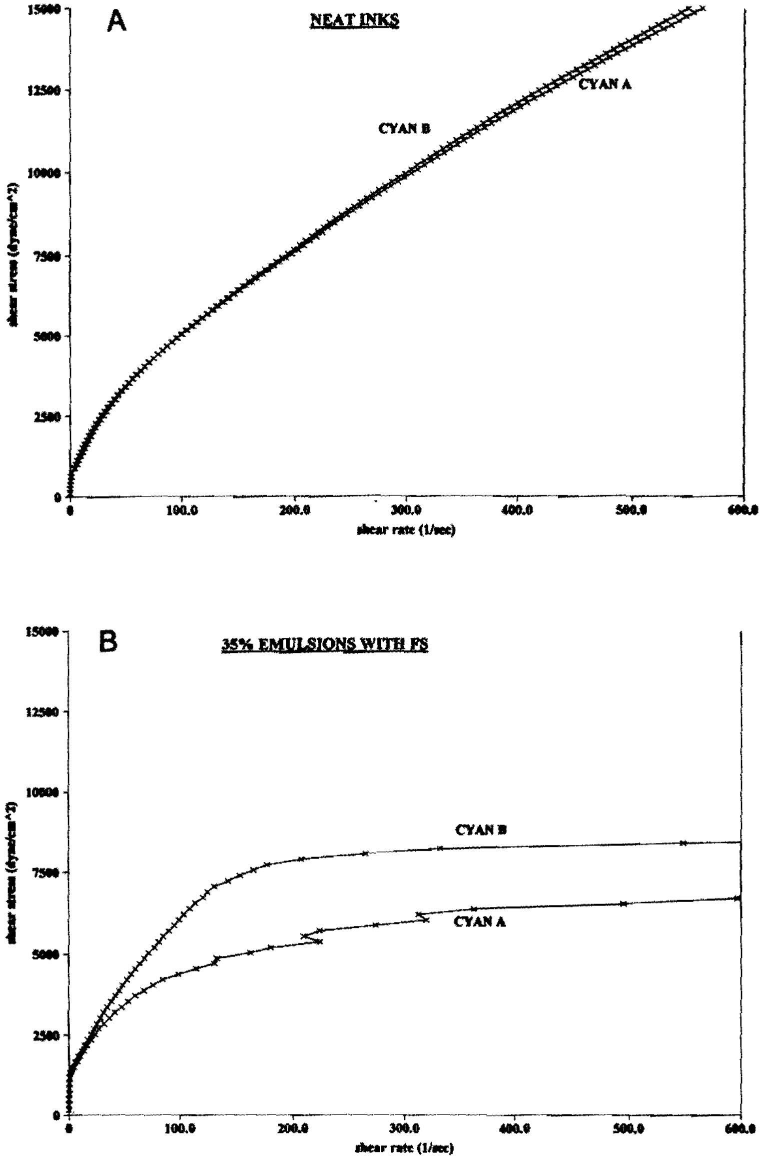

Figure 1. A - Neat Cyan Inks; B - Corresponding 35% Emulsions of Fountain Solution.

indicating a less structured emulsion phase. These speculations are reasonable, but better ways of emulsion characterization were sought.

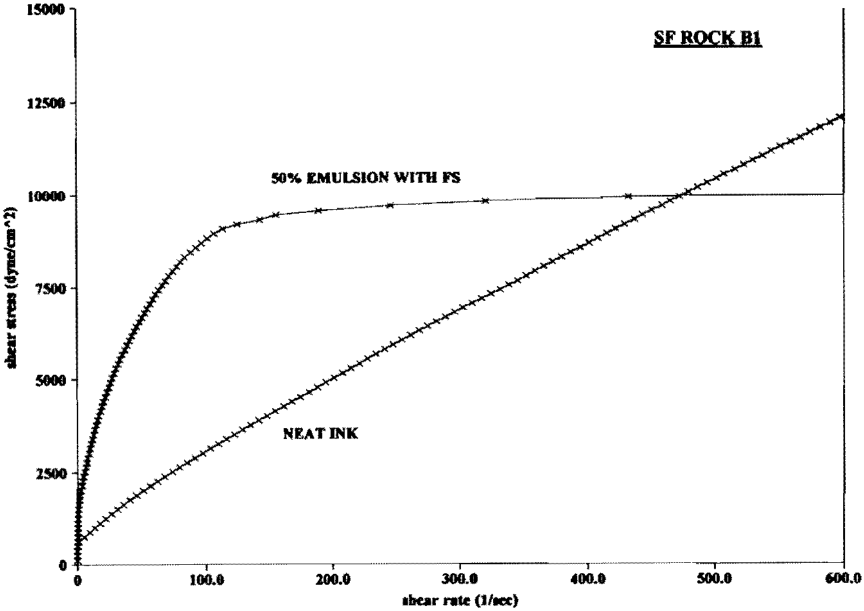

Figure 2. Neat Ink and Emulsion of Fountain Solution (50% by weight) of "Poor" Black.

Differential Scanning Calorimetry of Emulsions

Figures 5A and B contrast the two black 50% emulsions of "good" and "bad" single fluid inks. Note that the pattern of water endotherms is very different for the two emulsions. This is further evidence for differences in relative stability of the aqueous phase in these emulsions, lower temperature endotherm reflecting a more loosely associated water phase. This phase most likely contributes to surface water which is essential to maintain the cleanliness of the non-image area. The initial black SF ROCK B1 was capable of holding much water, but lacked a sufficient amount of critical surface water phase.

Thus, this method is useful for evaluating emulsion behavior during formulation and was crucial to producing four process colors which performed well on press.

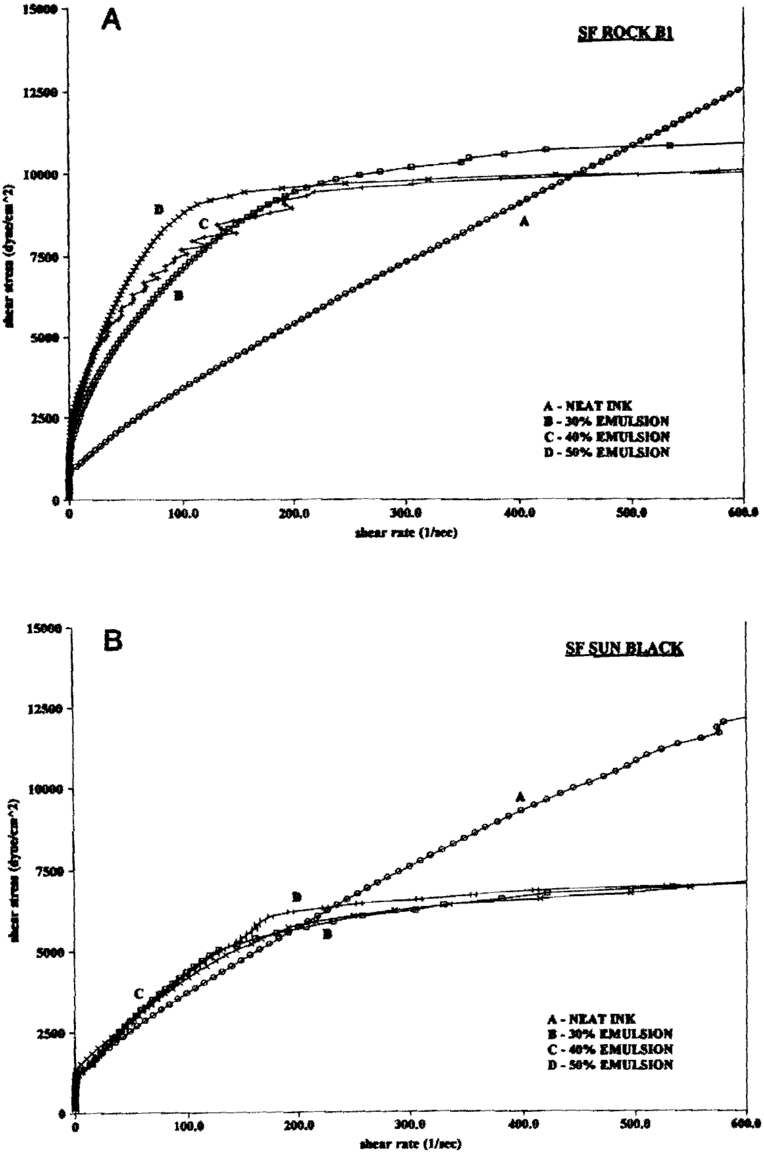

Figure 3. Behavior of Flow Curves as Function of Emulsified Fountain Solution for: A - "Poor" Black; B - "Good" Black.

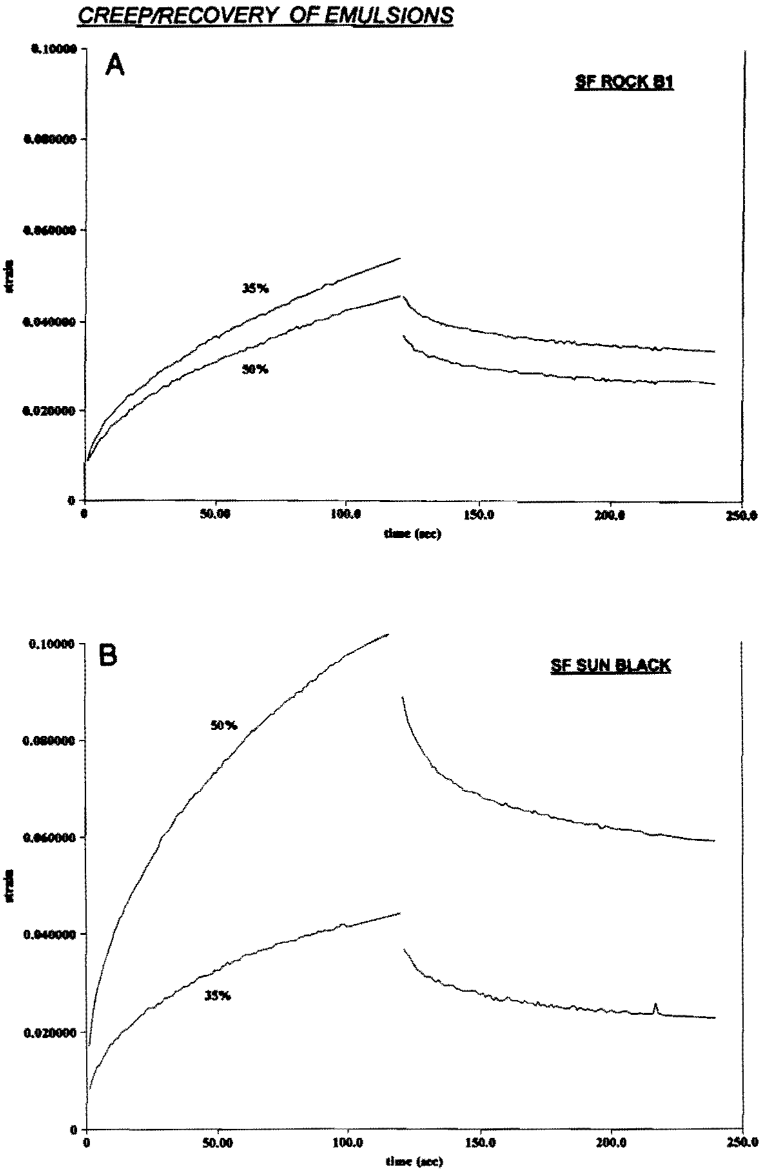

Figure 4. Creep/Recovery Curves for 35% and 50% Emulsions of Fountain Solution of: A - "Poor" Black; B - "Good" Black.

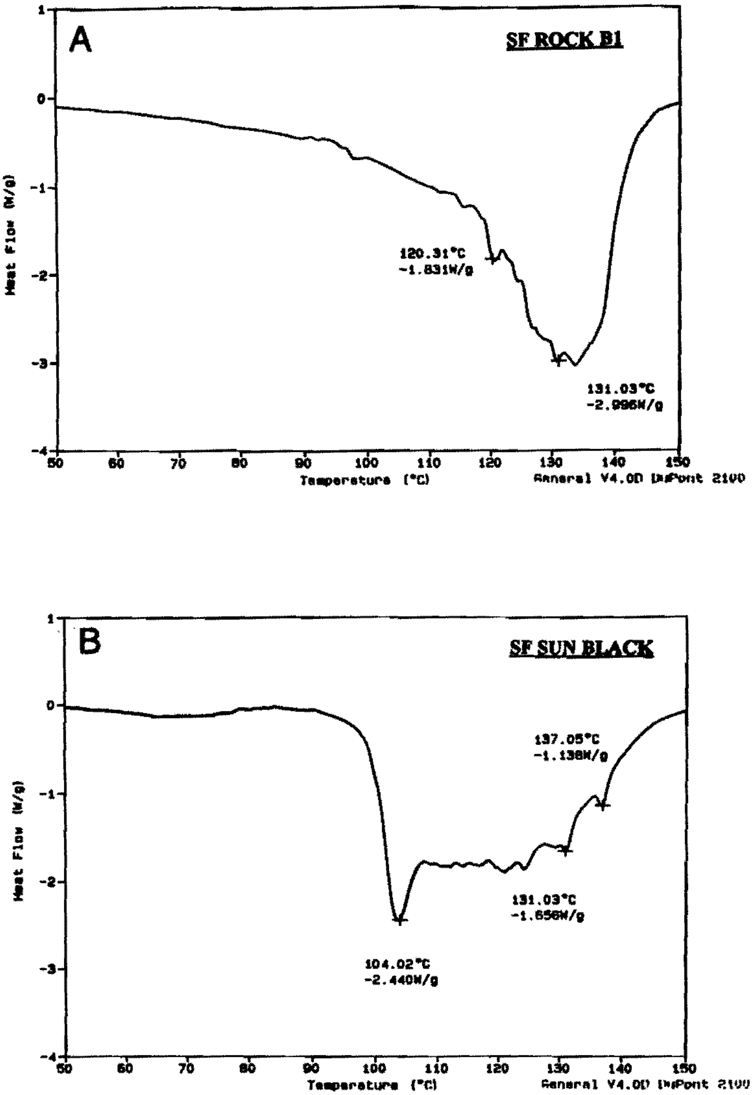

Figure 5. Thermograms for 50% Emulsions (with Fountain Solution) of: A - "Poor Black; B - "Good" Black.

Sensitivity of Emulsion Stability to Composition

Utilizing the characterization approaches described above, other colors were formulated. One particular case history illustrates the importance of chemical composition to successful single fluid lithography.

Figure 6 shows the behavior of a cyan formulation at controlled stress as a function of temperature. The shear rate is plotted here on the y-axis. The emulsion labeled A was run successfully on press at 35% emulsion. Emulsion B was another batch of the same ink. Note the evidence for extreme temperature instability. An examination of actual batch tickets of the base ink showed that in order to meet the physical specifications, an adjustment was made to one of the ink components (an alkyd). Emulsion C was the same as Emulsion B with a correction made in the amount of alkyd present. Thus, the emulsion

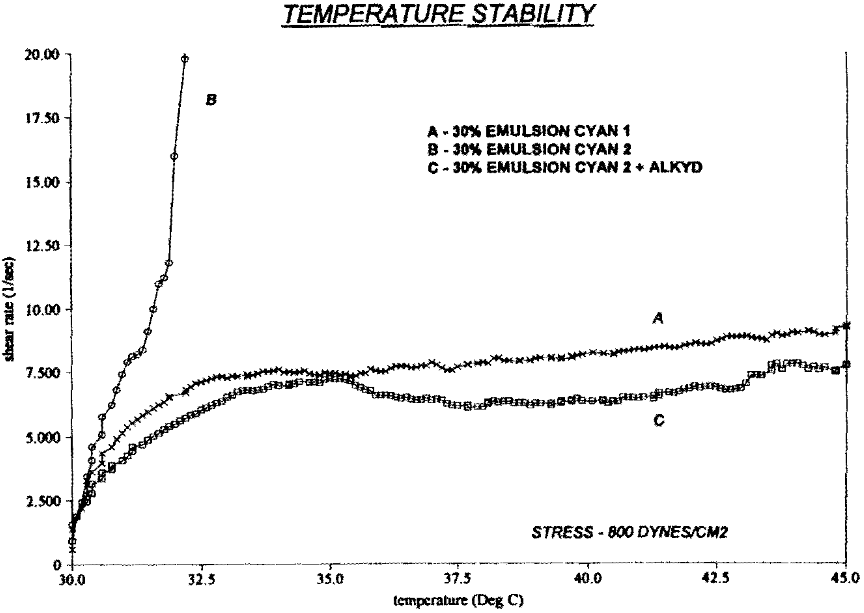

Figure 6. Effect of Temperature on Emulsion Stability of: A - Batch Cyan 1; B - Batch Cyan 2; and C - Corrected Cyan.

behaved, now, similar to the first batch. This batch then performed well on press. **Chemical composition directly impacts the single fluid process and at high content of water, exaggerates its role on emulsion stability.** This batch-to-batch variation is probably also the source of the distinction between the original samples of "good" and "bad" cyan inks, as described earlier in this paper.

Use of Tap Water

Fountain solution was used, initially, as the dampening phase. In order to simplify this variable, an ink composition suitable for tap water was sought. Using the characterization approaches above, ink chemistry can be manipulated in order to:

- Adjust the volume of the water phase needed to clean.
- Nature of water phase utilized (i.e. fountain solution vs tap water).

Thus, the direct control of interfacial chemistry affects the formulation strategy for achieving proper emulsion inks for the single fluid process. By altering ink chemistry, we were able to reduce the black ink's water content and run all colors at lower water levels. The move to tap water makes the process much more attractive.

Press Tests

A Goss Colorliner, modified with a positive feed keyless ink system, was used for all print assessments. The dependence of print qualities on press design and the use of emulsion ink were detailed in the previous paper. The key findings were:

- The emulsion ink produces print quality as good as conventional ink with dampening in keyless lithography.

- Solid ink density is dependent on water content (for the same ink feed curves) with decreases observed as emulsified water increases.

- Printing speed (up to 65 K impressions/hr) has no effect on optical density.

- Depending on the ink formulation, a wide range of water contents can produce clean copy even at very low coverage (e.g. 1%).

- Dot gain and trapping properties are equal or better than conventional lithography.

- It has been observed that for some inks using the same ink curve, solid ink densities can be maintained to be the same, whether printed as emulsion ink or via the conventional process. This indicates that transfer properties of the emulsion inks may be very different than the conventional process to compensate for the large dilution factor.

Conclusion

There are several important conclusions from this study:

- Given a press design to overcome coverage problems, it is possible to make the single fluid lithographic process viable.

- Emulsion rheology and stability can be controlled in a way to benefit press performance using rheological and thermal characterization techniques.

- A "good" lithographic emulsion has proper stability to shear, temperature, and time, which matches the window of performance for the process.

- The chemistry of the single fluid inks may be more important than physical properties. (For the single fluid process, interfacial chemistry at high water contents will be more critical than for conventional lithography.)

- Good print properties can be achieved from emulsion inks.
- Further work will be needed to fully optimize the process, but the viability has been established for this press/ink combination.

Acknowledgement

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Literature Cited

Bulloff, J. J.
1974. "Emulsion in Printing and the Graphic Arts" in Emulsions and Emulsion Technology; K. J. Lissant (ed.), Vol. 2, Marcel-Dekker (NY), pp. 559-637 and references cited therein.

Clark, G. F. and Pauer, J. J.
1963 U.S. Patent 3,073,707 (January 15, 1963).

DeSanto, Jr., R. F.; Carava, S. S. and Parkinson, H. B.
1991 U.S. Patent 4,981,517 (January 1, 1991).

Fitzgerald, F. C.
1922 U.S. Patent 1,406,837 (February 14, 1922).

Holmes, H. N. and Cameron, D. H.
1922 U.S. Patent 1,410,012 (March 21, 1922).

Mehl, J. V.
1932 U.S. Patent 1,958,311 (May 8, 1934).

Rowell, G.
1933 U.S. Patent 2,090,704 (September 13, 1933).