RECYCLING OF HOLOGRAPHIC PLATES

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ABSTRACT

This paper reports on what to do with unsuccessful holographic plates--as the glass recyclers are more interested in bottles than plates of glass.

I. FERRIC MAGIC

Suppose you've been overextending yourself for the last 18 hours working on the ultimate master and you've checked the Beam Balance Ratio for the last time and then you make the exposure, only to realize that you haven't restored the object light! The plate is fogged!

Don't shatter the plate into glass shards to slit your wrists; the fog to which you've just exposed your plate can be erased! I discovered this phenomenon by accident; while processing some 4x5 inch plates, I inadvertently immersed them in a Ferric EDTA bleach before the developer. Even after 15 minutes, in CWC2 developer, there was no developed density. (See Table I for formulae.)

Could the bleach have erased the latent image? Current theory on the process of exposure states that a small developable speck of silver is formed on the silver halide grain as the bromine is shooed away by the action of light. The Fe EDTA bleach, being of the rehalogenating family, replaces the lost bromine and restores the grain to its virgin condition. Even the ancient Daguerreotypists realized a fogged plate could be revived with a quick trip back to the Bromine box.

To test this hypothesis, I exposed a piece of 8E75HD film to room light, cut it in half, then bleached one part, and developed both together. There was no density on the bleached part. I next made a photogram on another piece of film by laying some coins on it, then cut it in half, bleached one segment and made a second coin photogram on it. The first exposure did not seem to bother the second.

Would this effect work for holographic exposures? An Agfa 8E75HD plate was fogged by room light, a sliver was cut off, and the remainder bleach-erased and given the same exposure dose and development as a normal plate. The reconstruction of both holograms were identical, yet the unerased sliver displayed density > 4 with the same development!

Sensitometric measurements of virgin plates are compared to Fe EDTA and PBQ erased plates in Table II. Although untreated and Fe EDTA plates are almost identical, it seems that PBQ gives a bit more speed. This may be anamolous, but then again holograms have been recorded in PBQ sensitized layers. (1)

A simple Ferric Nitrate bleach (Table I) was also tested for erasing effects, but this formula did not work, leaving the plate milky and useless. Another unsuccessful experiment was trying to erase a uniformly fogged and developed plate. To re-use the plate the mistake must be discovered and erased before development.

So, if you make a bonehead mistake in the dark, or your pulsed laser doesn't deliver a big enough pulse, or somebody walks into the lab and throws on the light, the plate is not ruined but salvageable.

The only difficulty is cosmetic, and lies in how well the plate is handled. A thorough wash (3-5 minutes) after a couple of minutes in the eraser, I mean bleach, followed by 1-2 minutes in Photo-Flo® and air-dried (all in the dark!) can bring the plate back to its original out of the box condition. If there are streaks, etc., the plate can still be used for feasibility studies.

II. SECOND CHANCE

Another use for fogged plates, implemented before the miraculous discovery above, was to fix out their silver halides and to dichromate the remaining gelatin layer. Starting with plates like this makes gaining DCG experience a snap since the coating variable is eliminated. Everyone is familar to some degree with this technique for Kodak plates either from experience or the literature, but papers dealing with Agfa derived layers are few and far between. I used the pre-exposure procedure outlined by Oliva, et al. (Table III)

Their fixing bath is simply 10% sodium thiosulfate; no hardening agents. The Agfa red sensitizing dye is removed in the methanol baths. Use your masks! Compatibility of that dye with Ammonium Dichromate remains to be tested. Their last bath is a soak in very hot water at 90°C, but accidentally boiling the plates didn't seem to make any difference.

I tried different concentrations of the sensitizer, Ammonium Dichromate, from 2% to 20%, and 5% worked just fine. Exposure to 488 nm light was in the tens of milli-Joules/centimeters squared.

At first the holograms were processed according to Steve McGrew's guidelines in Table IV. But the same results were obtained with only 30" to 1' immersions in the four baths in Table IV at room temperature.

Denisyuk style holograms of coins (what else?) and a small plane mirror to check replay bandwidth were recorded. The replay color was very close to that of the laser's, so good that real time fringes could be observed when the plate was replaced on top the coins which were glued to an Abramson type plate holder.(2) Wavelength upshifting could be coaxed out of the plates, but not the broadband effects (and noise) of the thick commercial pendant gelatins. But the efficiency is not as high as the latter since the gelatin coating after fixing is probably no more than 4 or 5 microns thick.

This process may be of interest to holographers in need of masters for transferring to photo-resist, as it is low-noise and wavelength preserving, with probably more sensitivity at the deeper blue end of the spectrum. Masters and transfers can then be made at the same wavelength in low scatter materials.

The really amazing thing about this process is that previously processed holograms and non-holograms can be put to use thanks to this process! I tried it with a mongrel assortment of plates, all of them first bleached in the above-mentioned Fe EDTA bleach to rehalogenate anything in the emulsion so that it can then be fixed out following the procedure in Table III. Pyrochrome processed plates were treated in the Stain Remover S-13 A and B baths (Table I) prior to that to remove the tan stain and soften the gelatin. Results varied, but most of these plates made successful holograms when they had a second chance!

III. HOLO-GNOMON

The gelatin can be dissolved off completely disastrous plates in a bath of sodium hypochlorite, better known as laundry bleach. The obvious use for such a plate would be to cap a good hologram, using a reliable epoxy or optical adhesive. Or a hole can be drilled through the center with a diamond bit, a nail stuck through it, and then a Xerox copy of Figure 1 can be glued to it for a handy reference beam angle measuring device! At 45° from the nail/normal, the shadow of the nail will be as long as the nail is tall. A circle whose radius is equal to the nail's height would identify a 45° incident beam if it were coming from top, bottom, left or right or anywhere inbetween! Figure 2 shows the trigonometric relationships of the radii of the concentric circles with respect to the angle for those who like to draw their own. The nail/normal is dubbed a gnomon, like the shadowcaster on a sundial.

The uses for this device are many fold; measuring beam angles is a lot better than guesstimating them. Different reference angles for different sections of large collages can be coordinated. Shrinkage angles of triethanolamine concentrations can be measured. Angles of incidence for solar-powered environmental installations can be charted during the course of a day over the period of a year.

It can also be an aid to composition if the nail were piercing a transparent substrate like glass or plexiglass. The holographer would know when they are looking smack dab into the middle of the scene along the normal if only the head and none of the shaft of the nail is visible. Off-normal viewing angles can be sighted as in Figure 3.

This may be a good time to discuss adopting these devices to standardize nomenclature for hanging holographic displays. The rings name the angle of incidence measured from the normal. To describe the direction, I suggest using the hours on a 12 hour clock in the best fighter pilot jargon tradition--i.e., 45 degrees from the top would be 45° from 12 o'clock high. But because the shadow is contrary to the source this requires an upside-down counterclockwise face. The last coordinate, distance of the source from the hologram is all that needs to be known to replicate conditions at the holographer's studio out in the field. To avoid any confusion the holographer could include a nail and the card with its shadow drawn on it when the hologram is shipped. Then there would be no excuse for the display crews not to hang it properly!

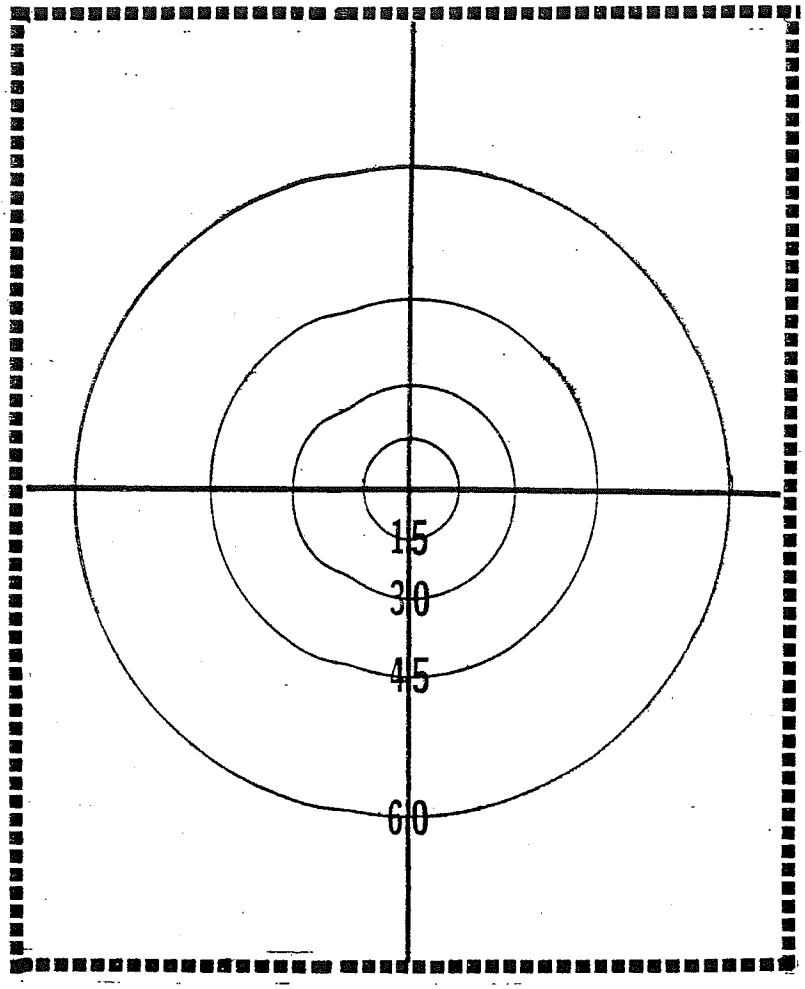

Figure 1. Whatever is used for the gnomon must be perfectly perpendicular to the plate and must extend 25 millimeters from the surface for this calibrated set of circles.

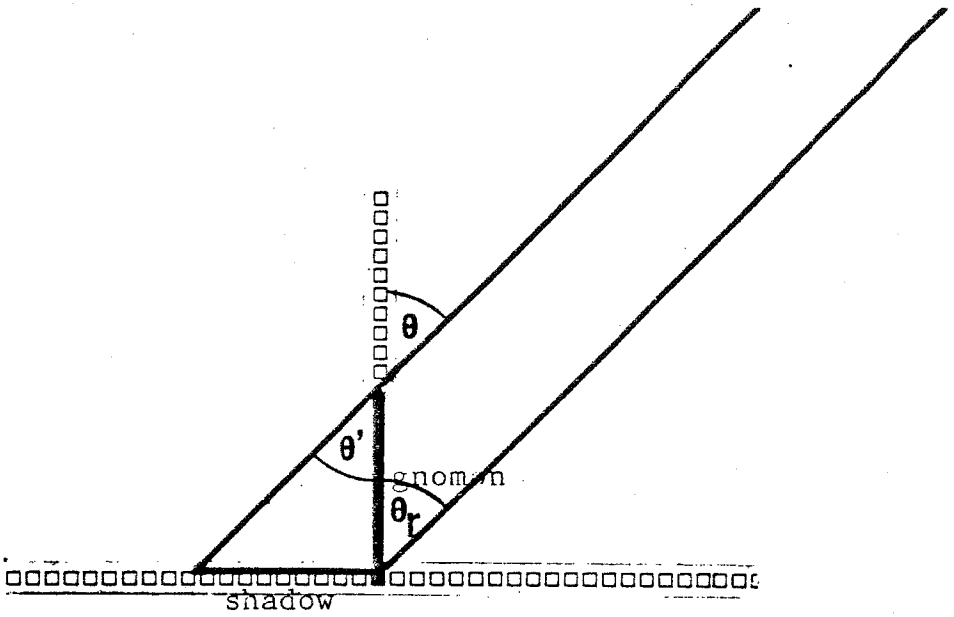

Figure 2. $\theta_r = \theta$ if the incident beam is collimated. $\theta = \theta'$ by the Vertical Angles Theorem. Then Length of Shadow = Length of Gnomon times tan θ_r.

Accuracy to better than 1° for a 25mm gnomon is ensured if the reference beam is more than 1.03 meters away. The proof of that is left to the reader. (Hint: Use the Law of Sines.)

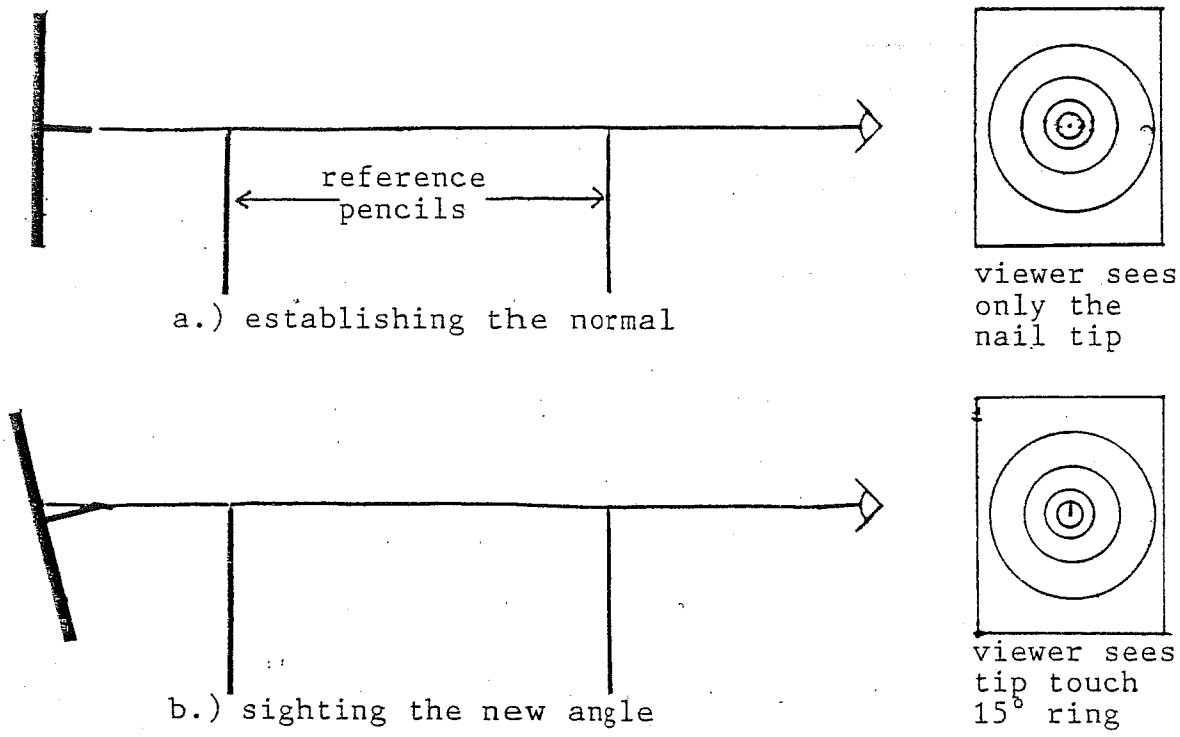

Figure 3. To determine off-normal viewing angles, first establish a normal line of sight using two reference pencils. Tilt plate so that gnomon touches desired angle's ring, for instance the 15° "Ward" angle.[3]

TABLE I. SILVER HALIDE PROCESSING FORMULAE

Fe EDTA Bleach
30 g Ferric Sodium EDTA
30 g Potassium Bromide
10 ml Sulfuric Acid
1 litre Water
Adapted from: Philips, N. J., holosphere Vol. 14, No.4, p. 21.

CWC2 Developer and PBQ2 Bleach

Developer	Bleach
10 g Catechol	15g Citric Acid
5g Ascorbic Acid	50g Potassium Bromide
5g Sodium Sulfite	2g p-Benzoquinone (Beware!)
50g Urea	1 litre Water
30g Sodium Carbonate	
1 litre Water	

From: D. J. Cooke and A. A. Ward, Applied Optics Vol. 23, No. 6. p.934. The Fe EDTA bleach can be substituted for the PBQ one. Development time, 2 minutes @ 20°C.

Simple Ferric Nitrate Bleach
150g Ferric Nitrate
30g Potassium Bromide
1 litre Water
Dilute 1 + 4 before use
This is the Agfa recipe GP431, holding the phenosafranine.

Stain Remover S-13

Bath A	Bath B
2.5g Potassium Permanganate	10 g Sodium Bisulfite
8ml Sulfuric Acid	1 litre Water
1 Litre Water	

One minute in each bath @ 21-27°C
From R. L. Lamberts and C. N. Kurtz, Applied Optics, Vol. 10, no. 6, p. 1342.

TABLE II. SENSITOMETRIC DATA FOR ERASED PLATES

Sample	Relative exposure to uncalibrated white light 1X	2X	3X	4X
Virgin Emulsion	.23	.41	.95	1.88
Fe EDTA erased	.21	.44	.89	2.20
PBQ erased	.23	.73	1.81	3.25

density units

TABLE III. PRE-EXPOSURE PREPARATION OF GELATIN PLATES DERIVED FROM AGFA 8E75HD

1. Fix in 10% Sodium Thiosulfate solution for 15 minutes.
2. Wash in running water for 15 minutes.
3. Wash in Methanol for 10 minutes.
4. Wash in clean Methanol for 10 minutes.
5. Soak in hot water (90°C) for 6 to 12 minutes.
6. Sensitize in 5% Ammonium Dichromate solution for 2 minutes.
7. Air dry.

All steps at 20°C except where noted.
From J. Oliva, P.G. Boj, and M.Pardo, Applied Optics, Vol. 23, No. 2, p.196.

TABLE IV. PROCESSING SCHEME FOR AGFA DERIVED DCG PLATES

1. Soak in Kodak Rapid Fix with ¼ hardener for 2 minutes
2. Soak in Photo-Flo 200 solution, 43°C, 5 minutes.
3. Soak in 30% water, 70% isopropanol, 53°C, 5 minutes.
4. Soak in 100% isopropanol, 70°C, 5 minutes.
5. Dry rapidly in warm air.

During testing, the processing devolved to 30" to 1' soaking times at room temperature with no change in the final hologram.
From S. P. McGrew, SPIE Vol. 215, p. 24.

TABLE V. REFERENCES

1. R. G. Zech, Hologram Recording in Thick Light-Sensitive Polymers, a paper presented at the San Francisco meeting of the Optical Society of America, October, 1972.
2. N. Abramson, The Making and Evaluation of Holograms, Academic Press, 1981, p. 77.
3. A. A. Ward, Holographics International, Spring 1988, p. 22.