BLEACHING

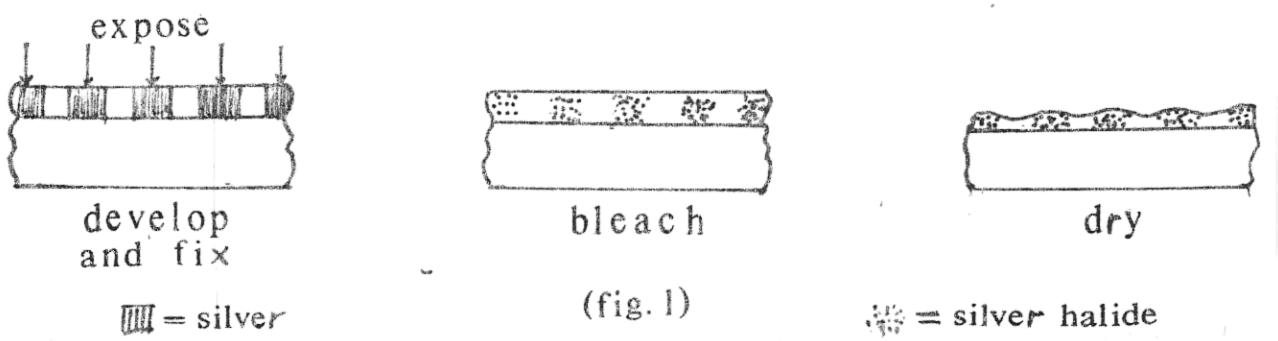
Photography uses the light and dark silver deposits on black and white prints or slides to tell us information about the amplitude of the light reflected from the subject. When holographers use silver halide materials they are not interested in recreating the amplitude variations (lightness and darkness) of the subject but in recreating the phase differences in the wavefront that came from it. Tonal variations in the hologram are a by-product of the phase information.

Silver halide materials are negative-acting; where more light hits them more silver is developed and the area is darker. Where less light reaches the material less silver is formed. Therefore an absorption hologram's fringes are dark where there was constructive interference and lighter where there was destructive interference in the recording process. In reconstruction the reference beam's light is diffracted through the gaps between the dark fringes into a zeroeth order and the object wavefront bearing first order. Much of the light incident on the hologram is absorbed by the dark silver deposits. This attenuation wastes light that could otherwise be used for a brighter image.

A method of increasing holographic image brightness is to change an absorption hologram into a phase hologram by bleaching. The bleach makes the hologram transparent so that more light will pass through, gaining diffraction efficiency and brightness. It retains its ability to modulate the phase differences into the beam by passing the light through areas with different indices of refraction which bend the light into the reconstructed wavefront by alternately slowing it down and speeding it up. Typically the substances that introduce these changes are the gelatin of the emulsion with a low index of refraction and a silver halide, either silver bromide (AgBr), or silver iodide (AgI) with their relatively higher indices of refraction. Bleached holograms must be exposed more to deposit the maximum amount of silver for the maximum index change.

REHALOGENATION

This type of bleach typically takes an absorption hologram that has been fixed and washed and changes the developed out silver crystals back into silver halides. It may take the form of a bath that contains potassium bromide or iodide which donates its halide to the silver crystal making it once again transparent silver halide. Some form of activating agent like potassium ferricyanide or ferric nitrate is added to start the reaction. Bromine, either as a vapor or dissolved in a liquid like water or methanol does a fine job of rehalogenating with the added bonus of added stability from printout.

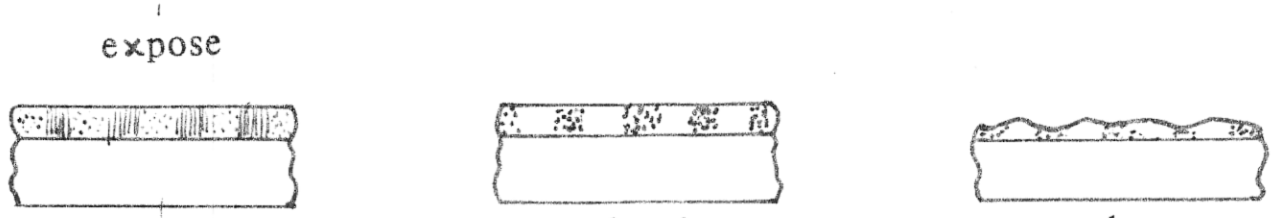


(fig. 1)

REVERSAL

These types of bleaches were originally designed for producing positive images on black and white photographic film. They also work well in producing low-noise phase holograms.

A developed and stoped but unfixed hologram is placed in the bleach which eats away the developed silver, leaving a residue of the unexposed and undeveloped silver halide. The areas of constructive interference are then represented by the gelatin, and the destructive interference by the left over silver halide. This is the reverse of the previous type of bleach, where the constructive interference is represented by the rehalogenated silver and the unexposed silver halides of the destructive interference where washed away in the fixer. The reconstruction mechanism is the same for both these types of bleaches, as the light passes through varying indices of refraction dispersed throughout the hologram. The reversal bleaches may be used either for transmission or reflection holograms.



(fig.2)

These bleaches either contain potassium dichromate or p-Benzoquinone (PBQ) to remove the silver. The PBQ bleaches also effect changes in the hardness of the gelatin to improve diffraction efficiency.

INTENSIFIERS

These bleaches do not produce phase holograms but are typically used in reflection holography. The mercuric chloride bleach rehalogenates the developed and fixed silver emulsion, and then it is "redeveloped" to plate out silver with mercury attached to it for high reflectivity. This bleach usually shrinks the emulsion, reducing the size of the fringe spacing and changing the color of reflection holograms recorded with red light to green. It's losing its popularity because the mercuric chloride is very poisonous and expensive, and the image is not very stable.

NOISE

Development brings surface relief to the emulsion by its tanning action. As the exposed silver halide is developed, the grain expands and so does the gelatin surrounding it. The gelatin gets hardened in these areas. The fixer takes out the remaining undeveloped silver halides, causing the gelatin to collapse in the undeveloped areas. This surface relief causes Optical Path Variations (OPV) and where light travels through a longer path through the gelatin, it can get refracted from the signal, causing noise.

In the rehalogenating bleaches, the areas of high index of refraction are also the areas of high surface relief, augmenting the low spatial frequency noise. (See fig. 1.) On the other hand, the reversal bleach takes out the silver in the high relief areas, leaving the gelatin in its hardened shape. The undeveloped silver halide is left in the low relief areas. (See fig. 2.) This tends to balance the index changes with the OPVs, minimizing the noise.

The choice of bleach depends on the intended use of the hologram, whether reflection or transmission, and the material being used. Kodak films don't respond well to Potassium Ferricyanide, but they recommend reversal bleaches. GP 432 bleach was designed for Agfa HD plates, and works well with others. Some bleaches are brighter but noisier than others. Personal preference comes into play here.

For successful bleaching, follow the recommended procedures and then fine-tune the process by trial and error to optimize the quality of the holograms. Bleaching technology is changing all the time; communication with other holographers will keep you abreast of the latest improvements.

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