# PYROCHROME

The **"Pyrochrome"** process was first brought to my attention by **Walter Spierings**, whom I met on a trip to the **Museum of Holography** in New York City in 1981. He was the Artist-in-Residence there, and was working on a three color rainbow transfer[1], but claimed that the processing he was using worked for both transmission and reflection. Most other holographers were skeptical that it would work for both modes.

His article on the process was published in holosphere[2] and the display holography world became aware of it. The process had actually been described a few years earlier, by Ruud van Renesse[3], and had its roots in an even earlier paper by Kurtz and Lambert[4].

The process gets its name from the principal ingredients of the two baths in the process, the **Pyro** part from the developing agent, **pyrogallol**, and the **'Chrome** comes from the oxidizer in the bleach, **potassium dichromate**. There is a wash after each one of these solutions, and the final step is a soak in a wetting agent.

**THE FORMULA for the developer** is as follows:

| **PART A** | **PART B** |
|---|---|
| 10 gm pyrogallol | 60 gm sodium carbonate |
| 1 liter water | 1 liter water |

Developing time 1 to 8 minutes at room temperature.

What could be simpler? The **Part A** is the developing agent, which is activated by the mixing of an equal amount of **Part B**, which is the alkali, to it. The combined solutions will oxidize into uselessness in about 15 minutes.

**Pyrogallol** is one of the first photographic developing agents, having been described by Fox Talbot himself. It has two interesting properties; it can seek out silver halide crystals that have been exposed to light and reduce them to pure elemental silver, but also the by-products of that process tan the gelatin surrounding the grain. Holograms developed in this stew have a characteristic tan color, not unlike the tan color one finds under the black of leather jackets, which is not so surprising, as pyrogallol is used industrially to do just that, so watch it with the fingers in the developer, as it does tan living flesh! The brownness can be removed with a soak in laundry bleach. The tanning is beneficial in holography as it masks the grain scattering noise of the material, making this developer the primary recommendation for the high speed holographic films like **Kodak Type 131/SO-253** or **Agfa 10E56** or **75** for bleached holograms.

Like any other developing agent, **pyrogallol** requires an alkali environment to do its job. **Sodium Carbonate**, ordinary washing soda, provides the proper **pH**, around 10.6. But once the pyro is in the alkali, it is very susceptible to oxygen in the water, and turns black as the oxygen atoms break into the long organic chain. Mixed solutions of **A** and **B** will last an hour at least, but it's at its freshest in the first 15 minutes. Even covering the developer tray with another just slows down the process so that the developer should be replaced in an hour or so.

The second **Pyrochrome** article in holosphere was written by Graham Saxby[5], and he doped up the formula by adding 1.2 grams of **Phenidone** to the **Part A** and doubled the amount of **pyrogallol** in it, (just forget about the sodium metabisulfate which he mentions), which increases the speed of **8E75HD** about three times. That meant cutting exposure times by a third, or to be able to holograph a plate three times the area with the same power laser in the same length of time. The results are identical to the above developer when used with the **'Chrome bleach**. The major drawback of this soup is the more than doubled price of the developer solutions. This developer is not recommended for the high speed films as they all too easily pick up density from spontaneous development fog. It has been used as a developer for pulsed laser holography, and is quite successful for transmission holograms, viz. "The Man on the Motorcycle" or "In the Lab" holograms, but not so good for pulsed single beam reflection. That is best left to the developer tailored for that job, **SM-6**.

**BLEACH RECIPE**

4 g Potassium Dichromate
4 ml Sulphuric Acid (Concentrated) or 12 g Sodium Bisulfate
One litre Distilled Water

Bleach till clear plus 15 seconds not to exceed two minutes.
(An equivalent, pre-mixed concentrate is available as Ilford Holographic Bleach SP679C)

The dichromate not only oxidizes the developed silver, it also donates a chromate ion to form a water soluble silver compound which is washed out, leaving the insoluble silver bromide behind. The exiting salts can oftentimes be observed leaving the holographic plate as a white powder. The plate should be bleached in this bath upside down but not touching the bottom of the tray or hanging vertically in a rack to efficiently remove everything, because salts left behind can accumulate as a scum on the surface of the emulsion. Water with a lot of minerals can also form a scum with the dichromate, so this bath is best compounded with distilled water. Even the rinses before and after the bleach may contribute enough minerals to form a white powder on the hologram, so a quick rinse in distilled water before and after the bleach will eliminate this noise.

The **'Chrome Bleach** dissolves the exposed and developed silver, so that the holographic pattern is represented by pyrogallol hardened gelatin where the bright fringes had been during exposure, while the dim fringes are represented by untanned gelatin containing silver bromide crystals which had not been disturbed at all by the processing. This is the reverse representation of the fringe system recorded by the classical processing scheme of develop the bright fringe exposed silver bromide grains to elemental silver and then dissolve the unchanged silver bromide grains in the dim fringes with a thiosulfate fixing bath and then change the developed silver where the bright fringes had been back into a clear crystal with a rehalogenating bleach, leaving the dim fringes represented by clear gelatin. Although the two holographic patterns are the inverse of each other, (Which is the positive and which is the negative?) the tonal reproduction in the hologram is just like the original in either case.

This bleach has its roots in the photographic processing scheme used to make black and white slides or movies directly on film stock exposed in a camera. Normally a negative which is tone reversed is the result of developing a camera exposure; but if this negative is bleached away by a dichromate bleach, then the remaining silver halide in the emulsion can be developed into a positive. In photographic terms this is called **"Reversal Processing"**, so this bleach is sometimes called a **reversal bleach**. Developing a holographic plate a second time would only lessen the efficiency, as the darkened silver would absorb the incident light. The silver halide residue remaining after bleaching introduces phase changes to modulate the incoming beam to produce the holographic image and doesn't attenuate the replay beam much.

Because the developed silver is removed from the emulsion, the holographic layer shrinks to a thinner state than its original condition, and the fringe spacing also shrinks proportionately. This means that reflection holograms will replay at wavelengths shorter than that of the exposing laser. More exposed and developed density means a greater shift toward the blue. The range of colors available using this processing trick and a Helium-Neon laser is golden orange to a yellowish green. Tuning in the color is accomplished by trial and error exposure and development tests. **Exposure Doses** of 100 microJoules per square centimeter should be in the center of the **exposure series**.

**PROCESSING SEQUENCE**

| DEVELOP* | WASH | BLEACH | WASH | PHOTO-FLO |
|---|---|---|---|---|
| | 2-3 minutes | until clear plus 15" | 2-3 minutes | 1-2 minutes |

***Developing time recommendations:** Two minutes for 8E75HD plates, one minute for film used for reflection holograms; four minutes for film or plates in transmission mode. Any times between one and eight minutes may be used to bail out over or under exposure.

In 1984, **Dr. Tung Jeong** asked me what was my favorite formula for reflection hologram processing. I told him that at this time it was the **Pyrochrome** system. When I received the next mailing from Photographer's Formulary[6], there was a listing for the **JD-1 Hologram Processing Kit**, which was the **Pyrochrome** system.

## REFERENCES

1. Should be a holosphere article on his Penroses' Triangle.
2. Walter Spierings, "'Pyrochrome' processing Yields Color-Controlled Results with Silver-Halide Materials", holosphere Volume 10, Numbers 7 and 8, p.1, (1981).
3. R. L. van Renesse and F. A. J. Bouts, Optik 38, p.156 (1973).
4. R. L. Lamberts and C. N. Kurtz, "Reversal Bleaching for Low Flare Light In Holograms", Applied Optics 10, 1342 (1971)
5. Graham Saxby, "Jottings From the U.K.", holosphere, Volume 12, Number 5. p.9 (1983)
6. Photographer's Formulary, P.O. Box 5105, Missoula MT, 800-922-5255.