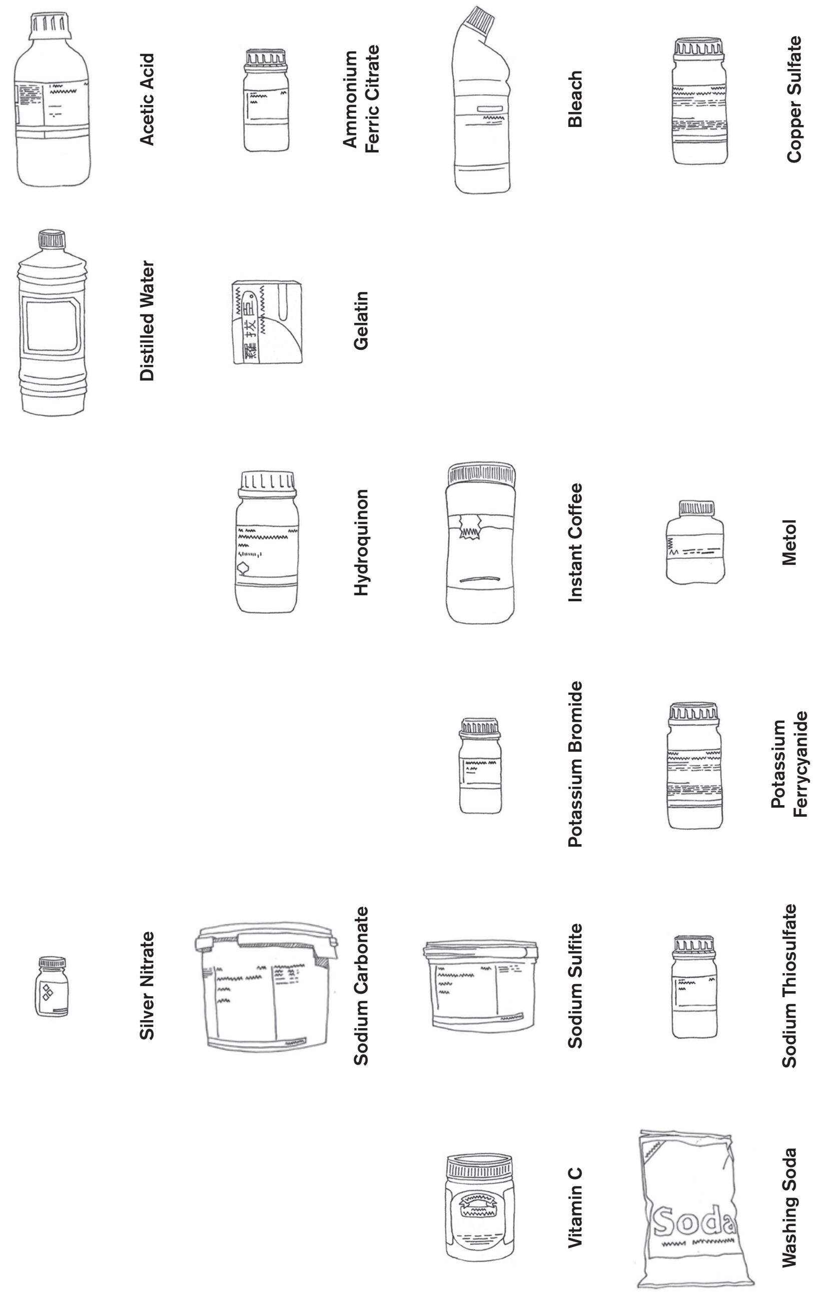
16 mm still plus-x negative

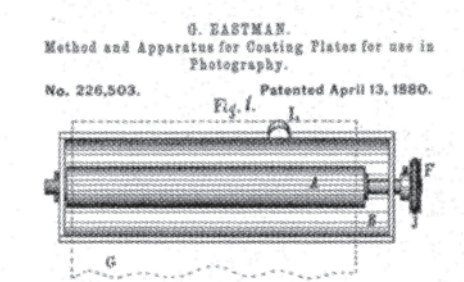


1. RE:INVENTING THE PIONEERS: FILM EXPERIMENTS ON HAND-MADE SILVER GELATIN EMULSION AND COLOR METHODS

To make your own emulsion is to embark on a journey into a different world of image making, one in which standard thinking must give way to physical realities that don't match convention. It's not going to be "as good," and that's beside the point. Ask, rather, what is it good for? What are its inherent properties, and how can they be worked with? We're not going to repeat Kodak's years of hard work in our basement, so why try? Let's do something else, something that they didn't do because it didn't match their objectives, neither aesthetically nor commercially. We don't have to sell it or be driven by a need to make money from it. That opens up enormous possibilities that Kodak could never pursue, burdened as it was by commercial necessity and the aesthetic conventionality this required. "Thoughts on Handmade Emulsion" – *Robert Schaller*, 2012

The tests and experiments made in this booklet are in the tradition of the pioneers. But though they were compelled to make steps forwards on this then new and unexplored matter, my interest and experiments are more akin to an opportunistic backtracking upon their findings.

Rather than completing accurate tests with the aim of producing standard film stock, I actually hope that through trial & error and the allowing of "happy" mistakes that it's possible to develop film material that in itself lends special cinematic effects. For me film is a lot more than the representation of what a camera has recorded – exposure and development. It's important for me that the emulsion has its own texture and can respond to chemicals differently then expected.



Images and texts have been gathered, harvested, illegally used, replenished and inspired by a plethora of found sources including those of Robert Schaller, Alex McKenzie, Brian Pritchard, The Light Farm, Ron Mowrey, the APUG site and many others. Thank you all, and a special thanks to Lichun Tseng for helping me out in the dark.

16 mm still plus-x negative

Apart from actual manufacture, the making of emulsions provides a scope for experiment pregnant with possibilities. Some knowledge of emulsion chemistry is of the greatest value in the general study of photographic processes. In the pioneer days, photographers had to make their own emulsions, and it was by the combined efforts of a small coterie of experimenters at the end of 1800 that the modern "dry plate" came into being. Some of these men were pure amateurs, others were practical chemists and men of scientific training. Out of this little band of experimenters came the founders of most of the original commercial emulsion-coating factories. The inevitable then happened. The businesses came into competition with one another, and further advances gradually became guarded as trade secrets.
— *Thorne Baker*, 1941

Re:Inventing the pioneers

This booklet is made as a starters guide to home brewing light sensitive emulsion that's suitable to use on 16mm clear (transparent) film. Most recipes on making your own silver gelatin emulsion are for photographic purposes and coating glass plates or paper. Practically all of these recipes can be used on strips of 16mm clear film. A black & white emulsion is easily made with some silver nitrate, potassium bromide and gelatin. It's actually similar to making mayonnaise. The biggest challenges are to evenly coat the emulsion on a strip of 16mm clear film and make it possible that the coated film can run through a printer or film camera.

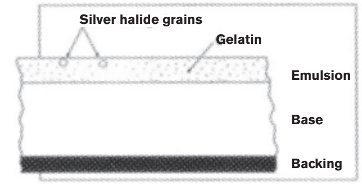
And.… I didn't want to make B&W film emulsion only, I wanted to go one step further (or actually back) by initiating a process that can put me on a trajectory where I will be able to make my own color film (in the literal sense). Not with the effort to find a way to make "proper" color stock with the realistic nature of contemporary film materials. In re-inventing emulsion and color film with the helping hand of technical publications from early cinema and photographic experiments, I'm hoping to achieve findings that are "something completely different and unique". This booklet is hopefully made with the same curiosity and in the context of, and as a tribute to, all these books and papers made by affectioned pioneers who where so keen to sharing their knowledge.

The starting point is the home brewing of a basic silver emulsion based on gelatin, potassium bromide and silver nitrate. To be able to resurrect the art, science, and craft of silver gelatin emulsions we need to experiment freely and share openly.
It signifies a hope and commitment to making sure these techniques, tricks and handy tips remain openly available to all who might need them. Let's not keep any secrets! These (chemical) recipes, celluloid experiments and emulsion extras should be absolutely public. Let's make home brew emulsion films! Let's make a lot!

My own tests where restricted to the 16mm film format. The pictures in this booklet of these tests are contact prints (as positive) from a Plus X negative (JK-blow up from Super8 original) to the handmade emulsion. The reticulation tests are done with outdated Svema 320 ASA negative material. All tests were started and made to end up in my film Konrad & Kurfurst: the home brew emulsion as fragile metaphor for the heroism of Konrad and his horse Kurfurst. Falling from his horse he became a national hero but overtaken by history, an anti-hero.

— *Esther Urlus*, 2013

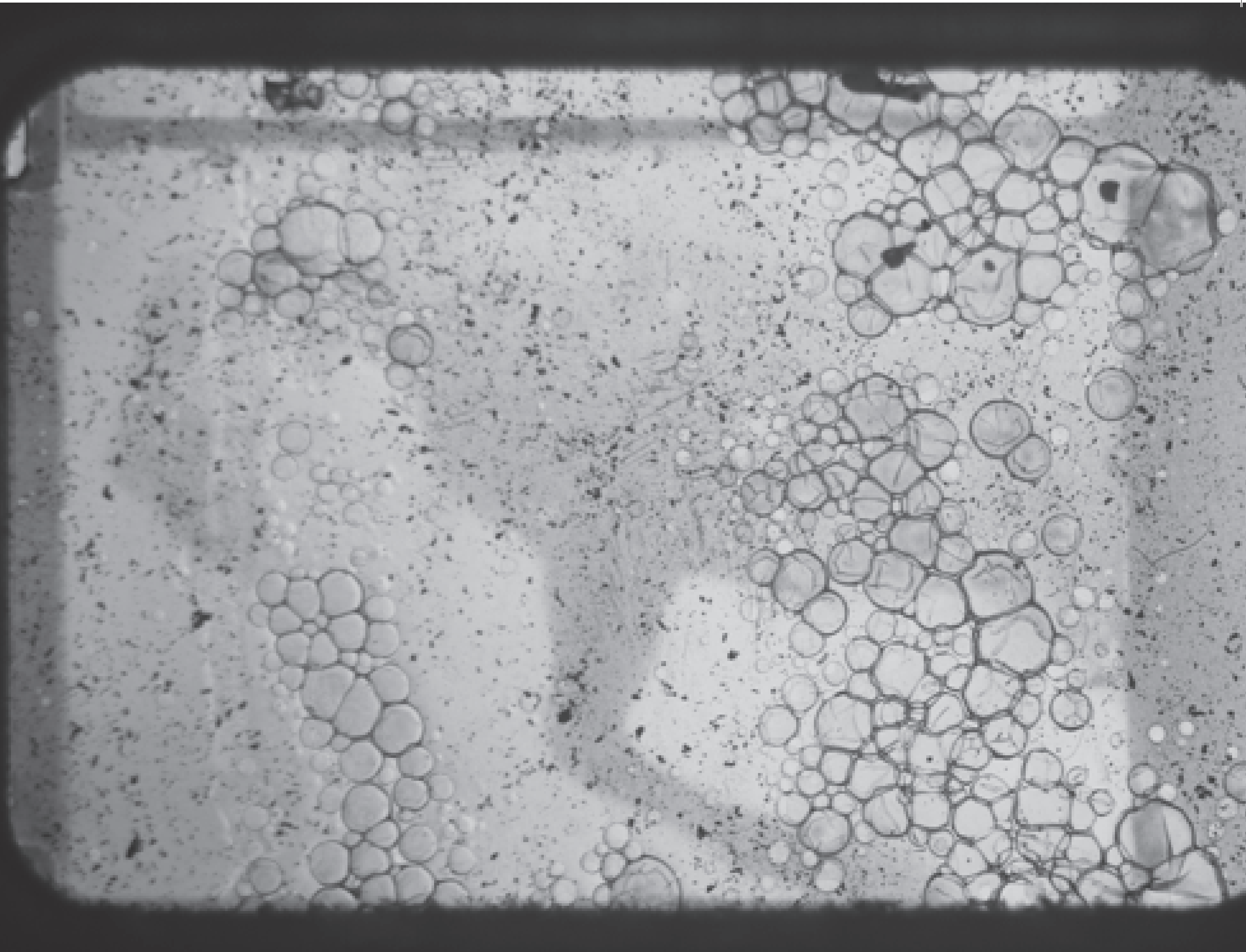
2. WHAT IS A SILVER GELATIN EMULSION



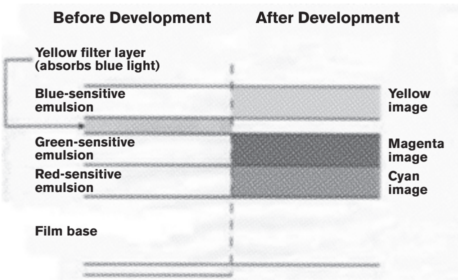
B&W Emulsion

Photographic emulsion is a fine suspension of insoluble light – sensitive crystals in a colloid sol, usually consisting of gelatin. The light – sensitive component is one or a mixture of silver halides: silver bromide, chloride and iodide. The gelatin is used as a permeable binder, allowing processing agents (e.g., developer, fixer, toners, etc.) in aqueous solution to enter the colloid without dislodging the crystals. The light – exposed crystals are reduced by the developer to black metallic silver particles that form the image. Fixer removes the unexposed silver halide remaining on the film, leaving behind the reduced metallic silver that forms the image. Color films and papers usually have multiple layers of emulsion, with dye couplers added. Layers of dye are coated between emulsion layers to act as optical filters.

**A solution of silver nitrate is mixed into a warm gelatin solution containing potassium bromide, sodium chloride or other alkali metal halides. A reaction precipitates fine crystals of insoluble silver halides that are the light – sensitive. The silver halide is actually being 'peptized' by the gelatin. The type and quantity of gelatin used influences the final emulsion's properties.
A pH buffer, crystal habit modifier, metal dopants, ripener, ripening restrainer, surfactants, defoamer, emulsion stabilizer and biocide are also used in emulsion making. Most modern emulsions are "washed" to remove some of the reaction byproducts (potassium nitrate and excess salts). The "washing" or desalting step can be performed by ultrafiltration, dialysis, coagulation (using acylated gelatin), or a classic noodle washing method. Emulsion making also incorporates steps to increase sensitivity by using chemical sensitizing agents and sensitizing dyes.**



16 mm still spray pump



Color Emulsion

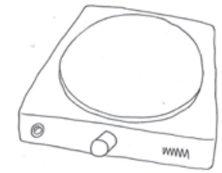
1 The Gelatin X

Gelatin belong to that class of substance known as colloids from the Greek meaning of glue. From the early days of gelatin – bromide emulsion it had been known that emulsions prepared in precisely the same manner but with different samples of gelatin might vary greatly in light sensitiveness. Gelatin–x, the presence of which in ordinary gelatin is largely responsible for photographic sensitiveness. Gelatin is made from skins and bones (mainly cows) which are made up from a series of proteins. The principle one is collagen from which gelatin is derived. The gelatin manufacturer went about producing a consistent product, however, it was found, soon after the 2nd World War when home photography came to the fore that if the skins were treated slightly differently during the washing phase the resultant product could have an influence on the light sensitive materials it carried in the film emulsion, making them more or less sensitive to light. Substitutes like Agar-agar has been employed with little success.

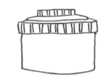
2 Color Emulsion

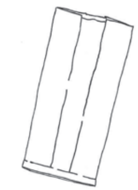
In black – and – white photographic film there is usually one layer of silver salts. When the exposed grains are developed, the silver salts are converted to metallic silver, which blocks light and appears as the black part of the film negative. Color film uses at least three layers. Dyes, which adsorb to the surface of the silver salts, make the crystals sensitive to different colors. Typically the blue – sensitive layer is on top, followed by the green and red layers. During development, the exposed silver salts are converted to metallic silver, just as with black – and – white film. But in a color film, the by – products of the development reaction simultaneously combine with chemicals known as color couplers that are included either in the film itself or in the developer solution to form colored dyes. Because the by – products are created in direct proportion to the amount of exposure and development, the dye clouds formed are also in proportion to the exposure and development. Following development, the silver is converted back to silver salts in the bleach step. It is removed from the film in the fix step. This leaves behind only the formed color dyes, which combine to make up the colored visible image.

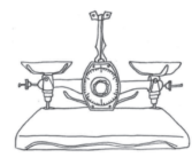
3. HOME BREW SILVER GELATIN EMULSION

Hot Plate


Pan

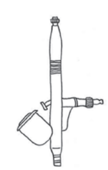

Containers


Film Bags


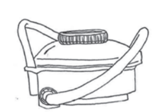
Scale


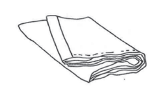
Syringe

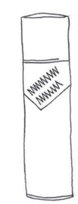

Timer


Airbrush


Cup with Hot Water

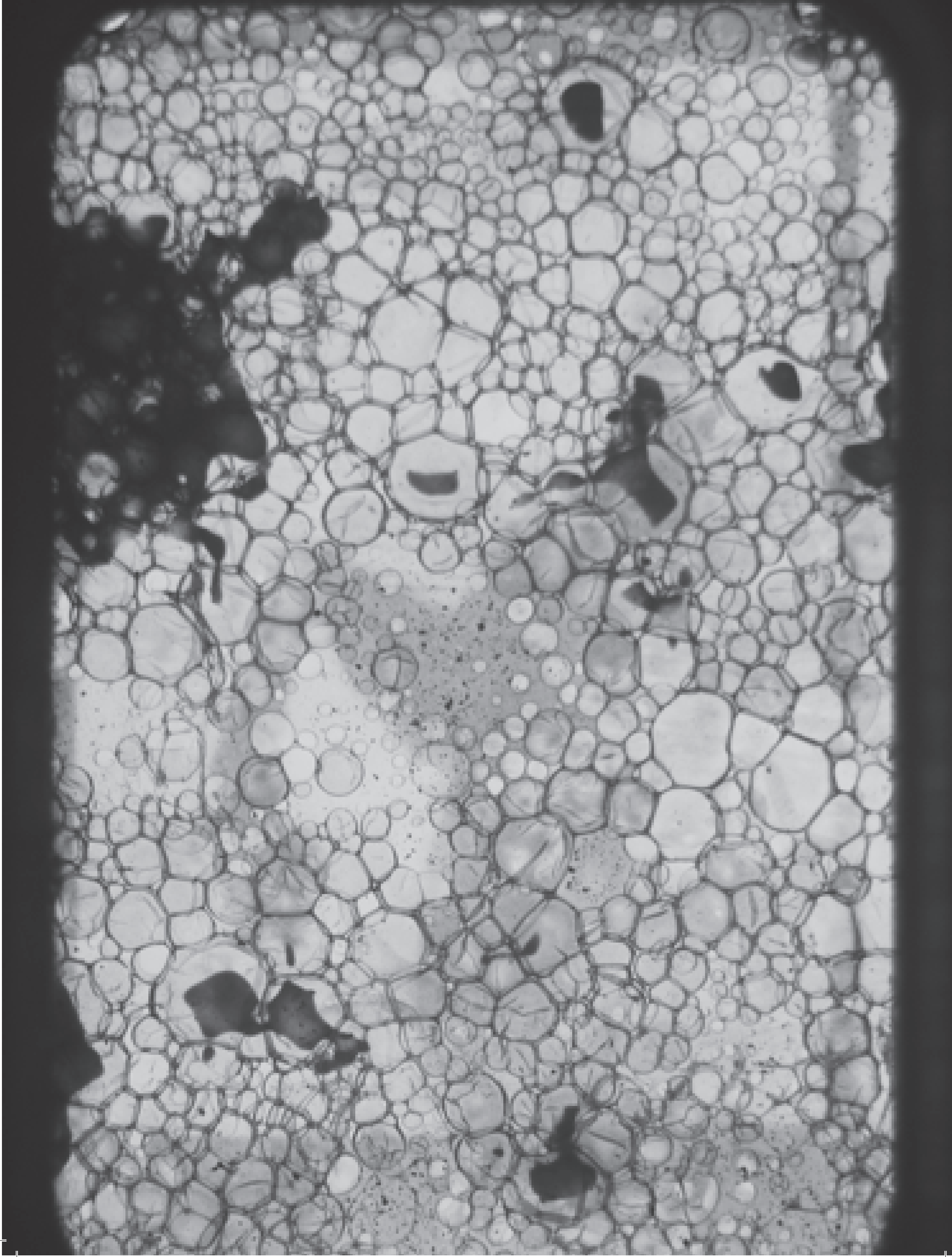

B&W Developer


Cheesecloth


Propellant


"To the beginner in emulsion making, the soundest advice that can be given is to avoid striving for high-speed emulsions, at first at any rate. It is infinitely easier to make a good slow emulsion than a good fast one, and while transparency emulsions will probably not content the tyro, it is just as well to start with these to learn the principles and manipulations, and then try for faster results, and even then to be satisfied with what would probably be called slow negative emulsions, that is up to about 150 to 200 H. & D. There are several factors that have to be taken into account which it is as well to clear up before starting on further details".
– *E. J. Wall,* 1929

16 mm still spray pump



Bear in mind that the emulsion needs to be mixed and painted in a dark room with safelight on, and so you need to be able to exit this room while it is drying etc without letting any light in on your way out! So the door needs to be either a rotating darkroom door, or it must lead to a hallway/room that can be made very dark. Working at night helps if you are doing this at home. Bear in mind that chemistry stains and is hard to track under red light, so take precautions if you are attached to your bathroom fixtures and porcelain / enamel.

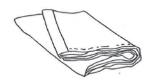
1 Materials needed

"It is of course convenient to have a special dark–room adapted for all photographic work, but in some cases, it is impossible, we are well aware. If, however, the amateur will work after dark, there is no reason why a dressing room, a bath room, or any spare room should not answer the purpose without permanently disarranging them."
– *William de Wiveleslie Abney*, 1885

1. **A hot plate.** (I use the cheapest stove element from a household warehouse).
2. **A cooking pan.** Put the pan with not to much hot water (50C) on the hotplate. In the water I put the small container with emulsion to keep the temperature constant. In kitchen terms "A bain-marie"
3. **Containers** for storage of emulsion (I use stainless steel photo developing tanks as they are all ready light tight. But all small containers with a sealable top will do. It needs to hold about 150ml max.)
4. **Light tight plastic film bags.** This is to ensure the emulsion is not exposed to any light once it has been mixed.
5. **Immersible (color) thermometer** that can be read in red light (digital thermometers are cheap and perfect for emulsion making particularly when they have a built–in alarm)
6. **Red (safe) light** (You could try to cover a tube light with red theatre lamp filters. Mine works perfectly)
7. **Scale** for measuring the powders (Needs to be accurate to as low as 0,1 gr. Bought my digital one in a coin collectors shop)
8. **Large plastic syringe** (or small jug) for measuring liquids (30ml / cc min.)
9. **Plastic spoons** (for stirring the emulsion)
10. **A surface or table** to lay the cleared film on and to paint or airbrush the emulsion on. A dark background helps when painting/airbrushing the white emulsion onto clear.
11. **Masking tape** to secure the film so it won't move around when being painted / airbrushed
12. **A timer / stopwatch**
13. **Clear film or cleared stock**
14. **Airbrush (starter set) or soft paint brush**, about 16–20 mm wide is nice, with a soft tip to pick up more emulsion
15. **B&W developer and fix** for processing.
16. **Cheesecloth or cotton** for washing the emulsion
17. **Rubber or latex gloves**
18. **Masks**
19. **Appropriate clothes**

2 Basic recipe: a very simple emulsion

A simple but highly effective recipe, producing a very slow emulsion (ASA 1) suitable for contact printing. It does not


Cheesecloth

produce a fast enough emulsion for any imaginable camera. This recipe is intended for contact printing, as the final material is quite fragile, it is recommended that it be treated as a negative (in development). The material is not suitable as viewing copy. Rinse all implements with distilled or demineralized water before use, and use distilled or demineralized water for mixes. Keep it clean.

Mix separately
(in normal room light):

Solution A

Gelatin – 10 g
(Knox brand (or equivalent) plain, unflavored food gelatin, from the grocery store
Potassium Bromide – 8 g
Distilled or demineralized Water – 62.5 ml

Add the gelatin to the water and allow to swell. Put the container (preferably stainless steel, but plastic works as well) into a water bath and raise the temperature to 50°C. Add the potassium bromide and stir or swirl continuously until both ingredients are dissolved.

Solution B

Silver Nitrate – 10 g
Distilled or demineralized Water – 62.5 ml

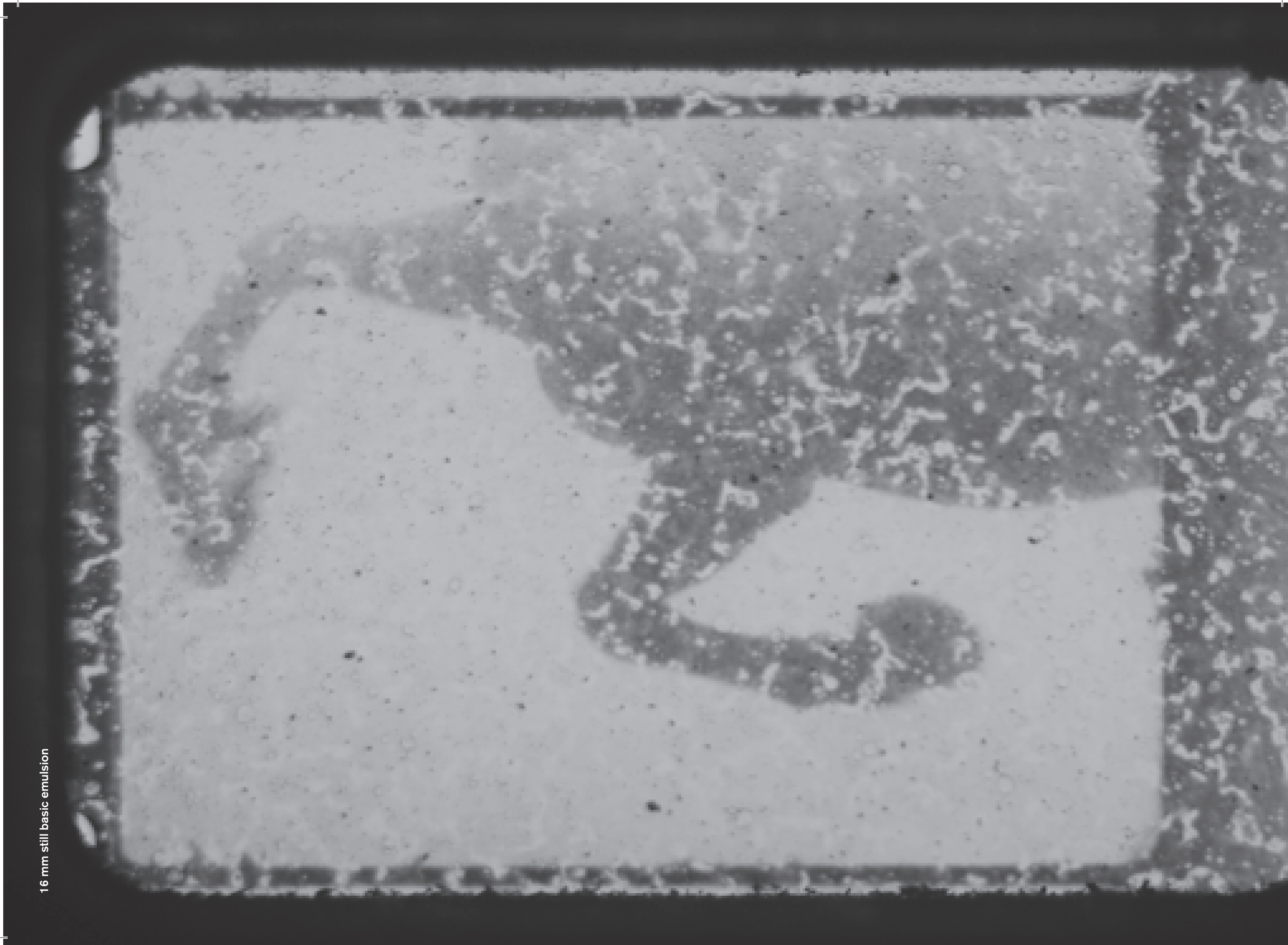
Dissolve the silver nitrate in the water by stirring or swirling, again, in a stainless steel container, and raise it's temperature to 40°C

The next steps must be conducted under a red or amber safelight.

Stirring continuously, add solution B to solution A in small, regular quantities, so that the addition takes 10 minutes to complete, about 5ml every 30 seconds.

The more slowly the silver nitrate is added, the larger will be the silver halide grains produced. And the larger the grains, the faster the emulsion.

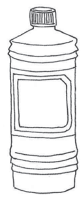
1. *Optional step:* Ripen the mixture. Keep the solution temperature at 50C for another 10 minutes, then let it cool slowly to 40C. The ripening process allows the size of the silver grains to grow, increasing the emulsion speed. Heat speeds the ripening. (The mixture can also be cooled until it gels and stored overnight at this point. Simply reheat when ready.
2. Finally, once it has cooled and set, filter the finished mixture through cotton or cheesecloth, make sure to thoroughly rinse the filter material with distilled water first.
3. Place the emulsion in a square of netting (about one-eighth-inch mesh) and fold the cloth over it. Hold the emulsion in a pan of cold water and twist the cloth so it is squeezed through the pores in the netting, making a kind of gelatin spaghetti. If no netting is available, use a square of cheesecloth or cotton and crumble the jellied emulsion by hand in small 6–10 square mm pieces. Fold the cheesecloth with crumbled emulsion



16 mm still basic emulsion

over a pan and pour cold water (around 15C) over the emulsion. Leave for a few minutes and refresh the water at least 3 times. This is necessary in order to remove excess silver salts.

4 *Optional step:* Melt and after–ripen. Melt the emulsion by heating to 55C for 15



Distilled Water

Gelatin

minutes, then slowly cool it to 40C. The after–ripening doesn't increase grain size much, but does increase speed.

5 The emulsion is now finished and ready to use. If not used immediately: refrigerate it in the meantime. Store it in a light-tight container, or simply place the container in which you mixed it inside a light–tight film bag. Make sure to label it so as not to open it accidentally in white light.

6 To use, heat so that the gelatin melts, 35C might be a good starting point, but the consistency will depend on the temperature, and so this will be a matter of personal preference.

Silver Nitrate

3 A silver bromide iodide gelatin emulsion

Gelatin – 10 g
Potassium bromide – 32 g
Potassium iodide – 0,8 g
Silver nitrate
Distilled water – 360 ml

1 **Dissolve the gelatin.** Dissolve 10 grams of gelatin in 360 ml warm distilled water.

2 **Dissolve the potassium bromide and potassium iodide**. Add 32 grams of potassium bromide and 0.8 gram potassium iodide to the gelatin solution and stir until dissolved.

3 **Heat the solution.** Heat the mixture to 130º F (55º C). The solution must be maintained at that temperature. The simplest way to do this is to surround the solution with a water bath.

4 **Lights out.** Turn out normal lights and work under a light red safelight.

Potassium Bromide

5 **Make a solution of silver nitrate.** Wear gloves when working with silver nitrate. Dissolve 40 grams of silver nitrate in 400 ml distilled water.

6 **Combine the silver nitrate and gelatin solutions slowly.** This is known as the precipitation stage. Add the silver nitrate solution slowly to the gelatin solution at a rate of 20 ml every 30 seconds for 10 minutes, stirring constantly. The more slowly the silver nitrate is added, the larger will be the silver halide grains produced--and the larger the grains, the faster the emulsion.

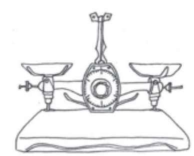
7 **Ripen the mixture.** Keep the solution temperature at 130º F (55º C) for a further 10 minutes, then allow to cool slowly to 104º F (40º C). The ripening process allows the size of the silver grains to grow, increasing the emulsion speed. Heat speeds the ripening. (The mixture can also be cooled until it gels and stored overnight at this point. Simply reheat to 104º F (40º C) when ready and proceed with step 8.)

8 **Swell additional gelatin.** Soak 40 grams of gelatin in distilled water until softened (20-30 minutes), then pour off the excess water.

9 **Combine the solutions** (emulsification). Add the softened gelatin to the silver nitrate solution and mix thoroughly. Cool the mixture and allow it to set (this usually takes 2 to 4 hours).

10 **Shred the emulsion.** Place the emul sion in a square of cheesecloth or cotton. Hold this in a pan of cold water and shred the emulsion, making a kind of gelatin spaghetti or ricotta cheese. This is necessary in order to remove excess silver salts.

11 **Leach out the excess salts (halides).**



Scale

Pour off excess water and place the shredded emulsion in a large beaker or other container. Pour 3 liters of cold water (below 68º F or 20º C) onto the shredded emulsion, let it sit for 2.5 minutes, then pour off 2 liters of the water and add 2 liters of fresh water.

12 **Repeat.** Repeat the washing process 5 times, using cold water. Pour off the excess water.

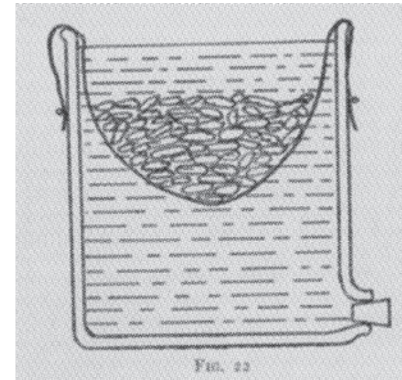
13 **Melt and after–ripen.** Melt the emulsion by heating to 130º F (55º C) for 15 minutes, then slowly cool it to 104º F (40º C). The after-ripening doesn't increase grain size much, but does increase speed.

14 **Coat.**

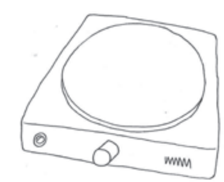
15 **Chill.** Leave the coated film flat until the emulsion sets, then leave in the dark to dry.

16 **Expose.**

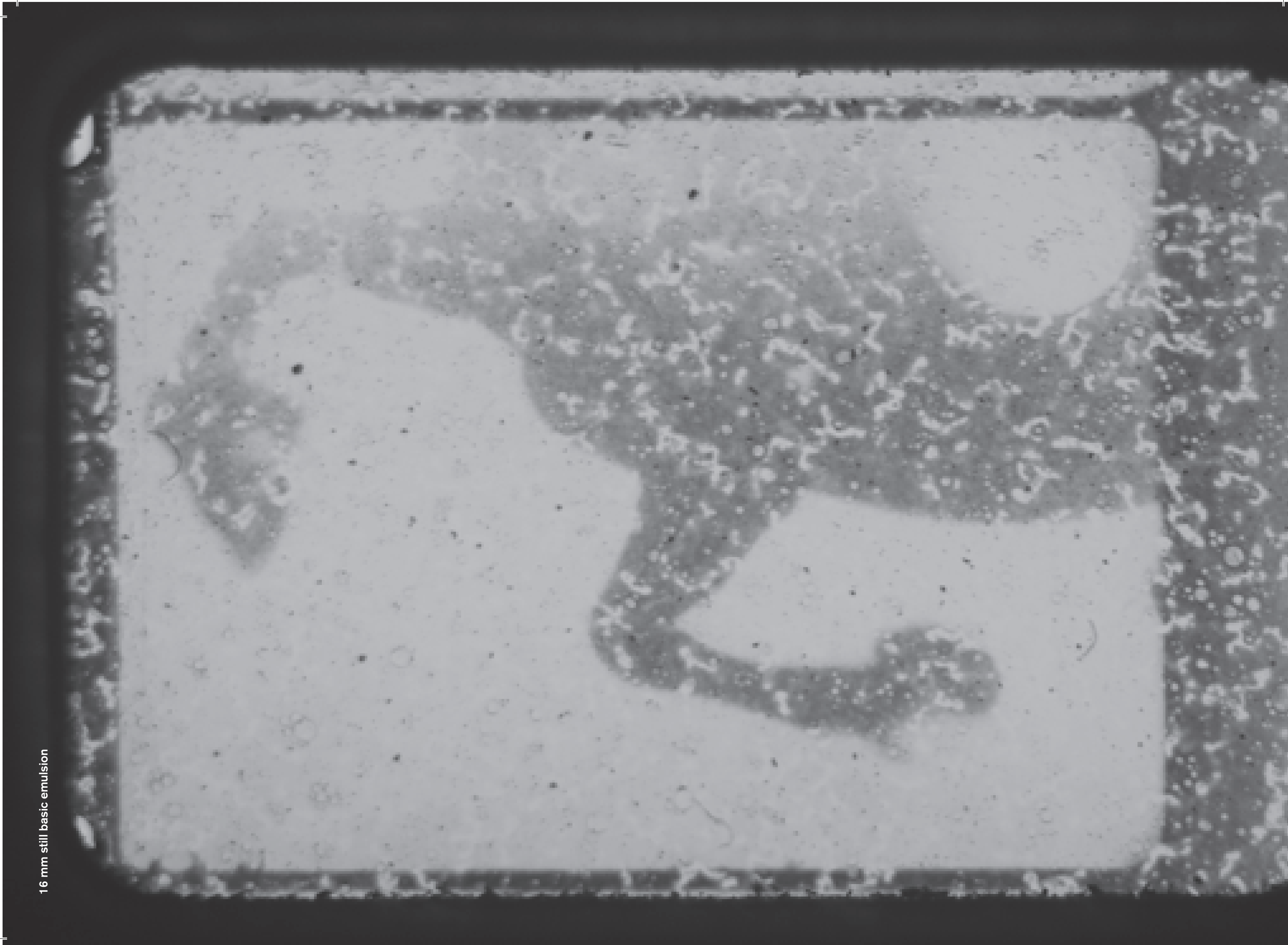
17 **Develop & Fix.** Develop in an active developer such as Kodak D-8 (2:1), HC-110 (Dilution A), or Dektol (1:1). Fix with a standard fixer.



Washing emulsion – *Baker*, 1941



Hot Plate



16 mm still basic emulsion

A real formula

Here is a real emulsion formula. At Kodak, we called this an SRAD emulsion (Single Run Ammonia Digest). This is adapted from one by Baker in his 1941s textbook on emulsion making.

Solution A

Potassium Bromide	132 g
Potassium Iodide	4.5 g
Gelatin	30 g
Water	1 liter

Solution B

Silver nitrate	130 g
Water	500 ml

1 Heat A and B to 45 deg C
2 Add 28% ammonium hydroxide to B with stirring until a clear solution results.

From here Red light only:
3 Add B -> A over 10 minutes
4 Hold for 30 minutes at 45 deg C.
5 Let stand for 2 hours or until at room temperature.
6 Shred into noodles and wash. (make sure all salts and ammonia are removed)
7 Remelt and adjust gelatin percent to the desired level (5 – 10%)
8 Add spectral sensitizing dye and hold at 45 deg for 15 mins.
9 Coat with a hardener and surfactant. I would use 10% glyoxal instead of chrome alum.
10 This can achieve up to ISO 40 speed.

Now, here come the caveats. This formula assumed, as they did at the time, that you were using standard (ACTIVE) photo gelatins, and you will be lucky if you get ISO 3 – 6 with it using modern oxidized photo grade gelatins. You cannot get active gelatins that are any good today, for the most part.

The only way to get speed is by chemical sensitization, or finishing. This involves the addition of any one of a variety of ingredients. The original was allyl thiourea, another was thiourea, and then finally they added sodium thiocyanate. Modern emulsions use either sodium thiosulfate or sodium thiosulfate plus a gold salt. It is done after the wash step, as excess halide represses this sensitization. This finishing step varies for every emulsion and sometimes for every batch of every emulsion.

The problem is that the quantity, time and temperature must be determined by trial and error as it is based on the surface area of the emulsion. This is a very complex procedure. This type of emulsion varies from batch to batch quite a bit in speed, contrast and fog.

BTW, this emulsion is polydisperse and the iodide that would otherwise be in the core and not very useful is churned by the action of the ammonia to be more uniformly distributed and therefore increases speed. This gives a rather high speed negative film with a long latitude and an upwardly bowed mid scale. (sound familiar?) Yes, this curve is very similar to some very revered products of the 40s, 50s and 60s.

Enjoy and have fun.

Kodak Research Laboratories in Rochester, New York, in 1920 – Courtesy of Kodak

4. RIPENING, WASHING AND DIGESTION

The sensitiveness to light of the emulsion depends to quite an important extent on the particular gelatin used, and its inherent "impurities." But it is also dependent on the method of precipitation of the silver halides, on the method and degree of ripening, and on the digestion which the emulsion receives after the by–products and excess solvents of silver bromide have been removed by washing.

1 Ripening

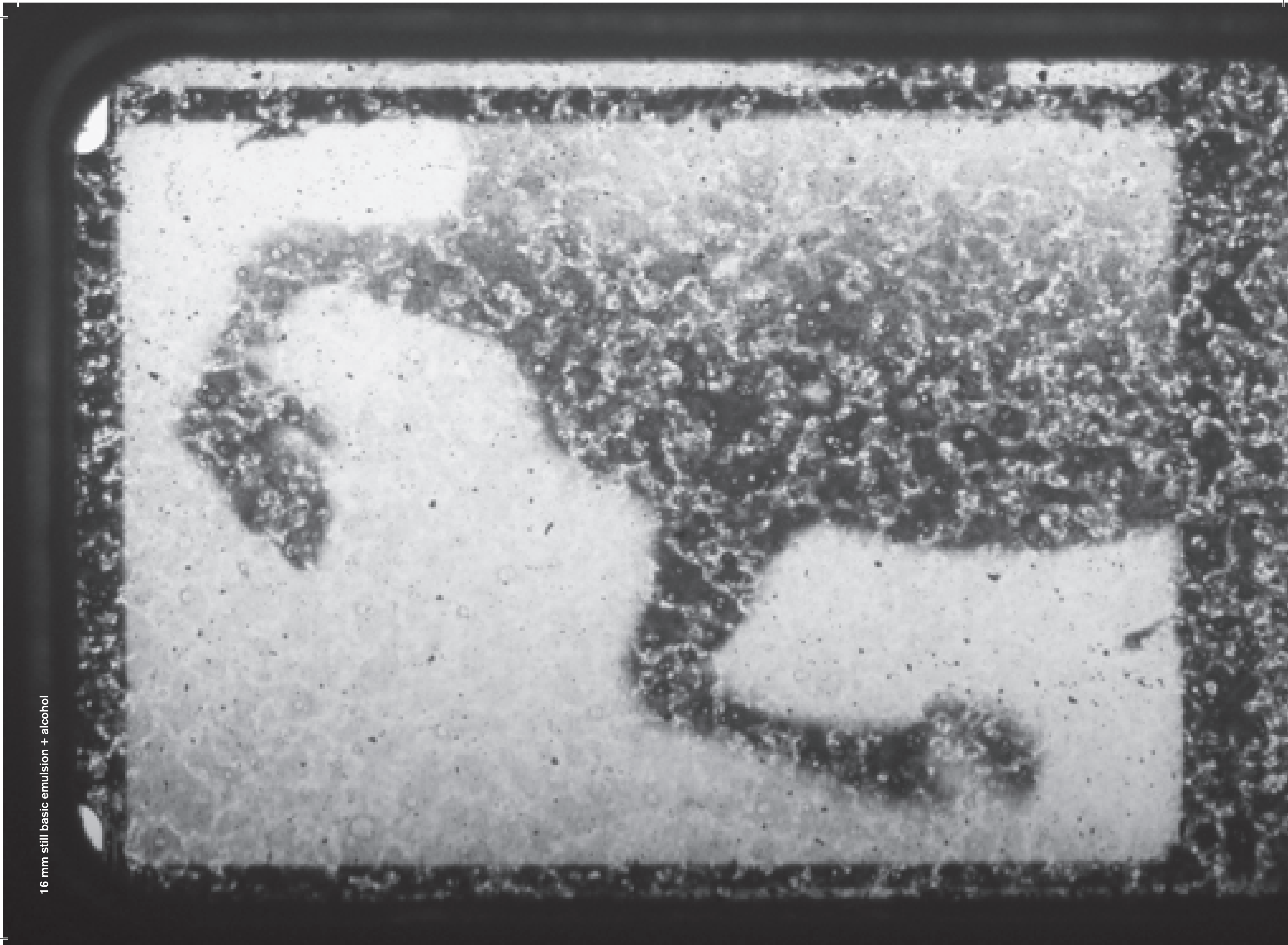
After emulsification the emulsion is kept at a temperature of 50C or more from 30 min. to 2 hr. This process is known as ripening. During this period the crystals increase in size; either the crystals clump to form larger crystals or the larger crystals increase in size at the expense of the smaller which disappear (Ostwald ripening). The latter is apparently the more important. The ripening process is favorably influenced (1) by heat, (2) by the presence of ammonia, (3) by iodide, and (4) by free halide and by the concentration and nature of the gelatin.

2 Washing

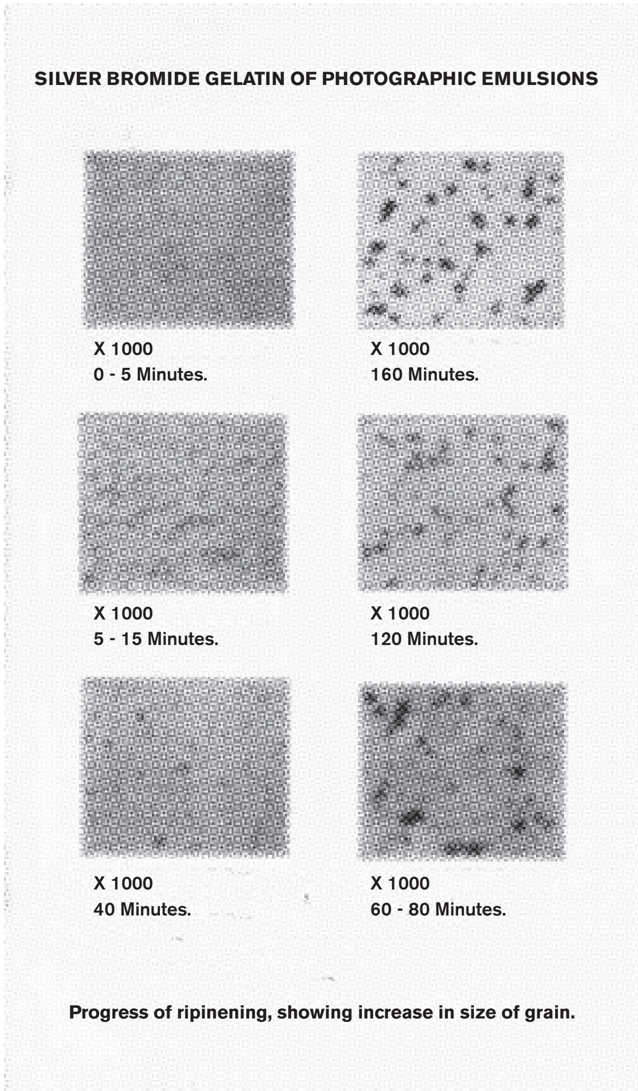
When ripening is complete the emulsion is chilled quickly to prevent further change and the jelly has to be broken into small shreds or "noodles." These are washed in cold (preferably) running water to remove the potassium or ammonium nitrate and excess bromide. Small lots of emulsion can be broken up by the hand to the consistency of ricotta cheese. A piece of cheesecloth or cotton (previously washed out) is tied over a jar or cooking pan. Put the shreds into the bag formed by the material, and fill the jar with water. Remove the water after five minutes and allow the shreds to drain. The draining may be made more thorough by teasing the shreds with a glass rod or spoon. The washing procedure is then repeated for about five or eight times. Here it may be stated that distilled water for washing has not proved satisfactory in general practice. If ammonia is used wash more thoroughly.

3 Digestion or after ripening

After washing, negative emulsions are again melted and heated to a temperature which varies, according to the formula, from 50C to 70C. for a period up to one hour. This operation is known as digestion or after-ripening. This second heat treatment, unlike the first, has but little effect on the size or the size-frequency distribution of the crystals of silver halide but results in a marked increase in their sensitivity to light. Carried too far, ripening leads to fog.



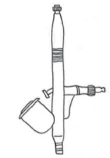
16 mm still basic emulsion + alcohol



The silver bromide grain
Trivellli ripening, 1921

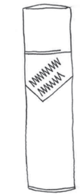
5. HOW TO GET THE EMULSON ON A (CLEAR) FILM BASE

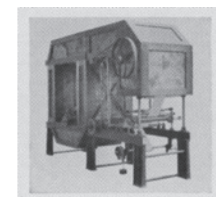
Airbrush



In factories film base is coated with emulsion in rolls of 36 inches/90 cm, or more in width and often 1000 to 2000 feet in length. The most common coating method in use involves passage of the film base beneath a roller which is immersed in a long shallow trough containing the liquid emulsion to be coated. Immediately after coating, the film is chilled either by passage through a "chill box" containing refrigerated air or by contact with chilled drums. The emulsion which is normally fluid at temperatures above 90F. sets rapidly to a gel at temperatures of 50F. and below. The sheet of chilled, coated film is then conducted by automatic machinery to the drying room where it is either looped and dried or carried over an arrangement of rollers continuously through the drier. The emulsion is dried by clean air of the proper temperature and relative humidity.
– *C.B. Neblette*, 1927 – 1951

Propellant

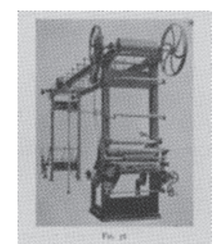




A compact subbing machine made by T.H. Dixon of Letchworth, England (1919-1940)

Film base

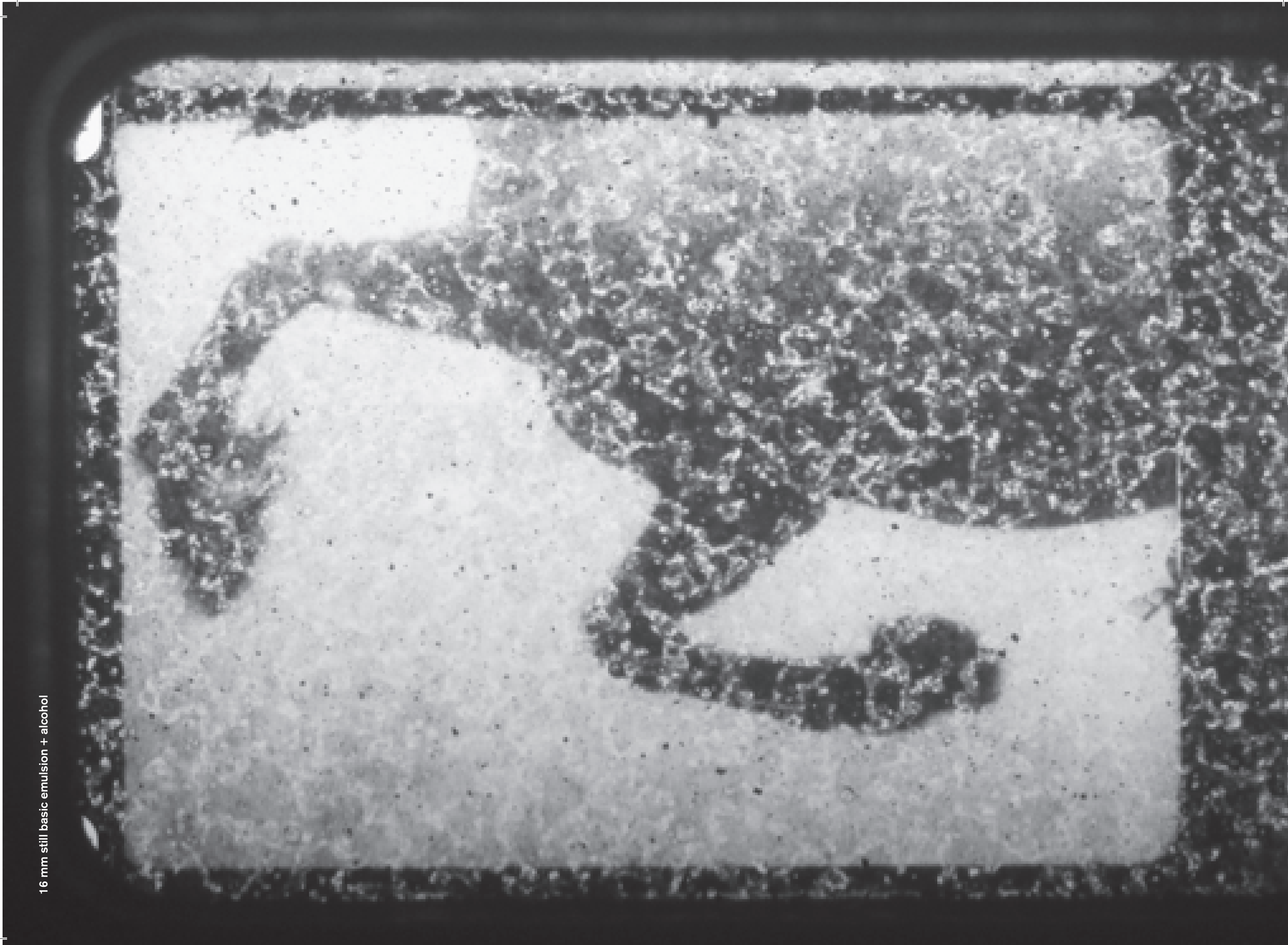
All photographic films are made up in basically the same way. The film base is usually plastic such as tri-acetate or polyester which is coated with a light sensitive emulsion. In photographic films and papers, the primary purpose of the base is to support or hold the emulsion in place. The base, or support, may be transparent or opaque, depending upon how the recorded image is to be used. A transparent base is used for transparencies that are viewed by transmitted light and for negatives that are printed with transmitted light. An opaque base is used for prints that are viewed by reflected light.



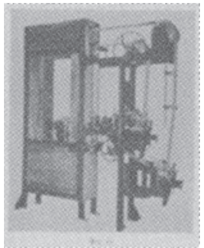
A small laboratory coating machine by T.H. Dixon and Co., Ltd., Letchworth, England (1919-1940)

How to make your own transparent clear film

If obtaining clear film through the official channels is to difficult or expensive: Make your own clear leader by bleaching old (found footage) film to clear the entire image with toilet chlorine. Sometimes commercial film-labs will let you have clear film/leader from startup prints if you ask nicely. Or use totally outdated unexposed film stock. Expose this film to light and drop it in fix till its clear. Rinse well.



16 mm still basic emulsion + alcohol



A double coating machine, also by Dixon and Co. (1919-1940)

Coating your film base

As to coating, the home brew emulsion sticks well to cleared acetate film that retains its commercially given gelatin coating, and seems to stick well enough to uncoated acetate, the clear leader you can buy in bulk. This will require some experimentation on your part. If you use cleared film with a remaining gelatin coating make sure you coat your home brew emulsion on this gelatin side. It is handy to have a flat surface or table to lay the clear film on so you can easily paint or airbrush the emulsion while it stays horizontal. Use plenty of masking or duck tape to secure the film on the table so it won't move around when being painted or airbrushed. Best to this in normal light. As the coating has to be done in red safety light in a dark room setting it helps if the surface where the clear film is taped on has a dark background. So you can see at least a little where the white colored emulsion is already coated onto the clear film. The table I used is two meters long (2 meter is ± 10 second in 16mm). I taped the film alongside each other in multiple (10 – 20) rows. With a line of white masking tape on both sides of the row to mark, in the length of the table, where the clear film is situated. And coated all rows of clear film in one go.

1 Airbrush

I had great fun (and results) in coating the film with a cheap Airbrush starter set (I used a Revell). These are easy to find on the internet and often used for painting miniature model making stuff. As the emulsion is not as fluid as water you need a 0.4 or a 0.5 spray mouth on your airbrush. And thats ± what a starter set offers. Nice mistake: air bubbles, as the emulsion dries quickly due to the cold pressurized air and a very thin layer of emulsion. I did extra tests with both extra water (10%) plus a tiny bit of hypo clear to avoid drying "too" quickly, as well as a few drops of alcohol (96%) to make the emulsion thinner. This I added in the home brew emulsion just before coating. See pictures for the test results. For my first coating experiment I used an air pump plant spray device. To see if I could coat the emulsion with it. The air bubbles where so big that an image was barely visible. It actually looked great but I doubt if I will use it in my film.

2 Using a Brush

Using a very soft brush that picks up a lot of emulsion can also be an option. Re–dip it frequently. Multiple coats are fine, and help build up enough thickness so that the maximum density of the final image is extremely high. You have to be aware, though, that too much thickness can make the film impossible to fix completely. Bear in mind that this is art, not science. If you want regular results, use commercial film and send it to a lab, but don't send hand-coated film to a lab. Coat on strips of a manageable length; say, about 1,5 meter / 4 feet. Dry in total darkness, and be aware that it is light–sensitive film!

3 Filmdipper

I tried to make a film dipper: Around 8 meter (=40 sec) of 16mm clear film rolled on a (drain pipe) tube and dipped into a tray filled with emulsion. This tube is placed inside a bigger one and closed on both sides, as being a light tight tank which i could store in a fridge. It didn't work for the simple reason that the water in the emulsion couldn't dry out in the light and air tight tank. The emulsion stayed soft and started to drip off the clear film and got mouldy. I found an example of a simple film dipper and of one using the "kissing roller" technique in the Thorne Baker book *Photographic Emulsion Technique* (1941). I'm considering this version.

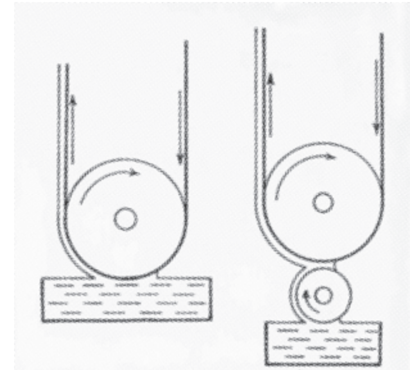
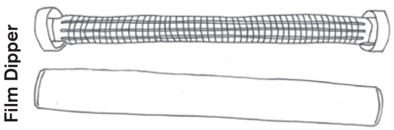


Diagram illustrating priciple of trough and roller coating machines. Left: filmdipper, right: kissing rollers (Baines, *Britisch Journal of Photography*.)

Film Dipper

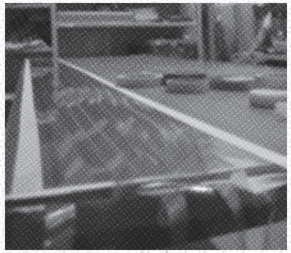


Soft Brush

16 mm still basic emulsion + water + H10

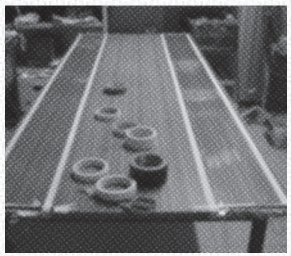
Taping the film on the table

1 Taping the film on the table

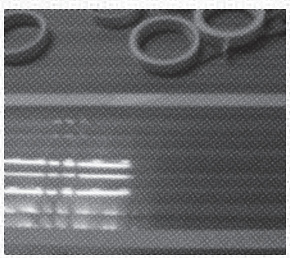


2 Taping the film on the table

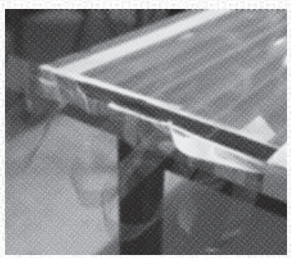
3 Taping the film on the table



4 Taping the film on the table



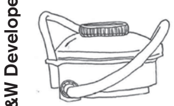
5 Taping the film on the table



6 Taping the film on the table

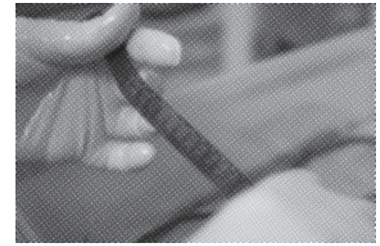
Esther Urlus, taping
the film on a table, 2013

6. EXPOSING & DEVELOPING THE EMULSION (as a negative)



1 Exposure

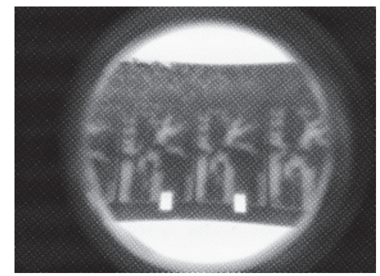
As the home brew emulsion is of such low sensitivity (around 1 or 2 ASA) the best way to get an image on your film is by using a printing technique. Keep in mind that the emulsion made by the basic recipe is light sensitive for blue and violet light. So the next steps have to be taken in a dark room setting with red or amber safelight.



Emulsion making

2 Dark room fotogram style

Place small objects directly on top of the film the emulsion. Stan Brackage did it with moth wings... Also grass, weeds, hair, skin, dust, feathers, pins, nails, sand, sugar, screws, pasta, salt and pepper will do, then exposed to light and develop. It will leave a nice contrasty negative silhouette impression.
In his exploration Man Ray called it "rayographs". His style capitalised on the stark and unexpected effects of negative imaging, unusual juxtapositions of identifiable objects, variations in the exposure time given to different objects within a single image, and moving objects as the sensitive materials were being exposed.



Handmade brushed emulsion

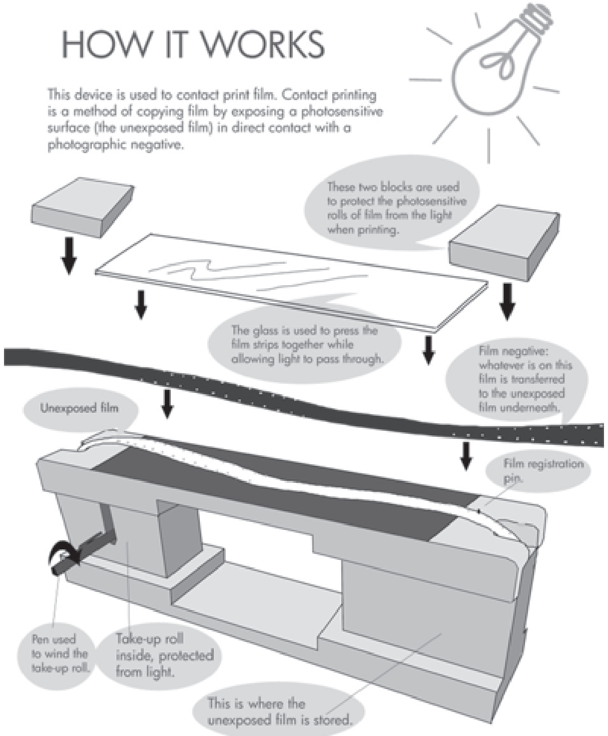
How to make your own

Sections of film are placed on a table your film underneath emulsion facing up and the objects on top. To get sharp, in focus images press film and objects together under a glass plate, and exposed one section at a time to light. This can be done underneath a photo enlarger as the area of light can be directed onto the film or using a hand held torch passed over the film. As with any exposure method, you will have to initially do test strips to get the best over-all basic exposure time depending on your light source. Exposures are not usually more than a couple of seconds as a rule and if you keep the development time constant, this will be the only variable and so this won't be hard.

3 Developing + Fixing

Develop in a standard developer and fixer. Use cold water for rinses, and make sure no solutions are over 20°C / 65 F, otherwise the emulsion might come off. Bear in mind

16 mm still basic emulsion + water + H10



Contact printing how it works by *Ashleigh Vaillancourt*

that the wet emulsion is very fragile and scratches easily, and that it is susceptible to veiling, running, and reticulation–all of which make working with hand-made emulsion exciting. You really should use a hypo–clearing agent at the end, as it is a silver image and will degrade if left contaminated with fixer, but the longer it's in any solution, the greater the risk of falling off, so use your own judgment. If you're just using it as an image source from which to print back onto regular film, this isn't an issue.

Small amounts of the 16mm film (around 2 meter / 7 feet) can be developed and fixed in photo trays or buckets. For bigger amounts its handy to have a Russian Lomo Tank, suitable for larger amounts of 16mm film (and Super8 and 35mm). Unfortunately these are hard to find. Building your own tank is also possible see the picture on http://www.peaceman.de/blog/index.php/selbstbau-super-8-entwicklungsmaschine.

4 A developing method

1 **Developer D-19** (3–5 min)
2 **Rinse** (2 times with clean water)
3 **Fix with a standard acid fixer** until all milky areas are gone, or as gone as possible (2–5 min)
4 **Rinse** (at least 5 times with clean water, or as long as you're willing to risk it)
5 **Hypoclearing or wetting agent**, any brand (1 min)
6 **Hang to dry**

5 Developer

There are minor differences in each manufacturer's developing chemistry but most contain the same basic chemicals. Each chemical has a specific function in the process.

1 **Reducer**: Chemical reduction of the exposed silver bromide grains into visible metallic silver is the function of the reducer. The reduction process is provided by hydroquinone, often with the compound Metol.
2 **Activator:** The activator causes the emulsion to soften and swell so that reducers can reach the exposed grains. Sodium Carbonate is usually used as the activator.
3 **Restrainer:** Potassium bromide is used as a restrainer to moderate the rate of development.
4 **Preservative:** Sodium sulfite, a typical preservative, helps protect the reducing agents from oxidation because of their contact with air. It also reacts with oxidation products to reduce their activity.

6 Fixing

The fixer solution clears the undeveloped silver halide grains from the film. The undeveloped grains leave the film and dissolve in the fixer solution.

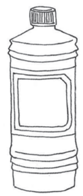
1 **Clearing agent:** Ammonium or sodium thiosulfate are clearing agents.
2 **Preservative:** Again, sodium sulfite is used as a preservative in the fixer solution.
3 **Hardener:** Aluminum chloride is typically used as a hardener. It shrinks and hardens the emulsion.

7 Safety

The silver (a heavy metal) that accumulates in the fixer is toxic to aquatic life. The silver can be removed from the fixer by electroplate in a silver recovery unit. Best to retain the fixer and send it to recyclers for this process.

16 mm still brush

Acetic Acid



Distilled Water

8 RECIPE FOR B&W DEVELOPER + FIX

D19 developer recipe

recipe for 1 liter

Metol – 0.2 g
Sodium Sulfite (Na_2SO_3) – 90 g
Hydroquinon ($C_6H_4(OH)_2$) – 8 g
Sodium Carbonate (Na_2CO_3) – 52.5 g
Potassium Bromide (KBr) – 5 g
Water at 120 degrees F/50C to make 1 liter

F5 ACID FIX

recipe for 1 liter

Hydroquinon

Sodium thiosulfate – 240 g
Sodium sulfite – 15 g
Acetic acid, 28% solution –
Boric acid crystals – 7.5 g
Potassium alum (hardener)
Water at 125 degrees F
to make 1 liter

Sodium Thiosulfate

Cool down before use!
A working temperature close to 65 degrees F (20C) is best. Higher temperature demands more care to protect the surface of the emulsion.

Sodium Carbonate

TF–2 Alkaline Sodium Thiosulfate Fixer

Metol

Distilled water – 1 liter
Sodium Thiosulfate – 250 g
Sodium Sulfite – 15 g
Sodium Metaborate – 10 g
Water to make 1 liter

Potassium Bromide

TF–2 is for users who are determined to use sodium thiosulfate rather than ammonium thiosulfate and who would like a formula superior to the traditional acid hypo fixers. TF–2 will wash out of negative and print materials more rapidly than will an acid fixer.

Sodium Sulfite

USAGE

Fix the film for three times the clearing time, usually 3 to 5 minutes. Follow with a two minute wash in running water for film. A hypo clearing agent is not required.

7. PRINTING A NEGATIVE TO A POSITIVE

Bolex

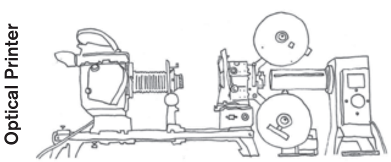
Contact Printing

This is the method used by the lab to copy film. A contact print is made on a machine called (sensibly enough) a Contact Printer, in which the original film and unexposed print stock are sandwiched together, emulsion against emulsion, and are run at a constant speed past a light which shines through the original, exposing the print stock with the same image. A lens is not necessary, and there is always a magnification of 1. The film format cannot change, 16mm stays 16mm. Basically all work prints, answer prints and release prints are contact prints. The only other type of printing is Optical Printing, which is usually done to add an effect or to blow up or make a reduction print.

Optical Printing

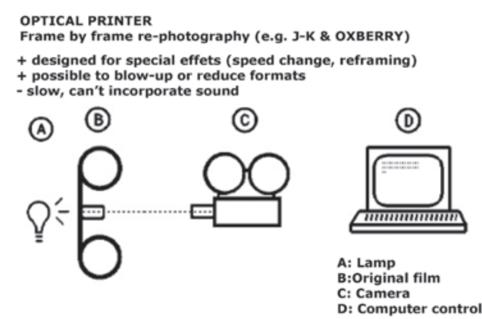
Basically, re–photographing film frame by frame. Normally through a film camera re–filming a projected image frame by frame. This is a way to make a copy of a film with many more possibilities than contact printing, but, at least with 16mm, resulting in a little added contrast and a little loss of clarity.

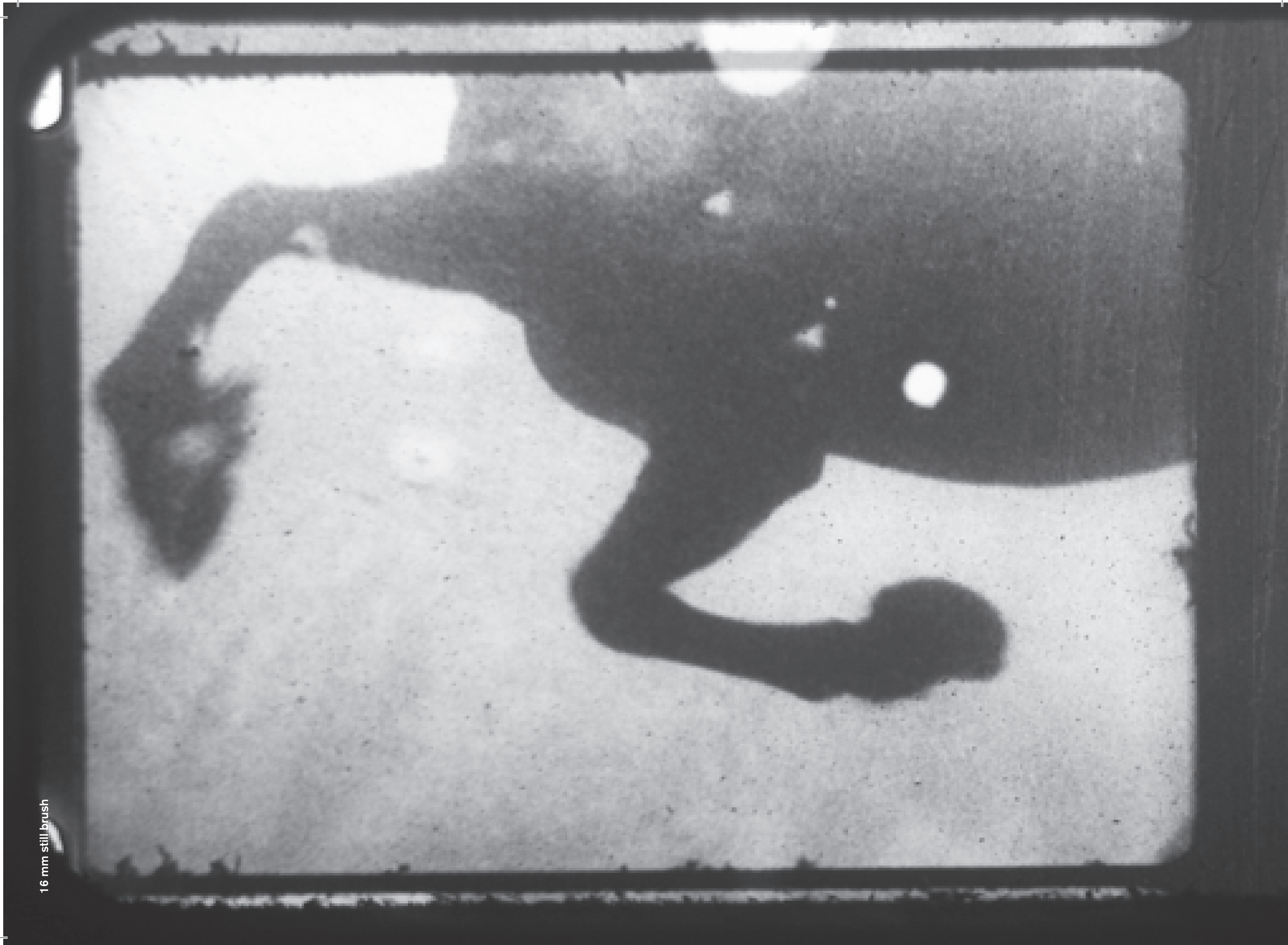
Optical Printer



DIY contact printing ways

Adjusting a flatbed editing table, by-packing in a camera (Bolex), with a picture synchronizer, a torch light: In fact, anything that transports film could be adapted. You only need to include a light source. And keep in mind: emulsion side against emulsion side, and run at a constant speed past a light which shines through the original, exposing the print stock with the same image.





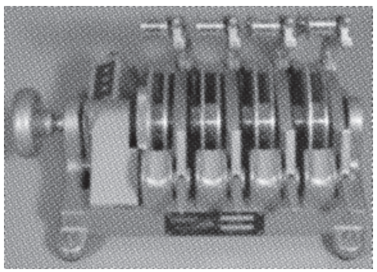
16 mm still brush

1 Double loaded camera

The camera itself can be loaded with negative and print stock in the dark room and then run without a lens allowing light to expose the stock. Longer sections can be done this way but the camera has a tendency to jam with the double thickness of film, so a hand crank assist is useful. Do exposure tests before attempting a mega length. For max. 10–15 meter / 35-50 feet.

2 Flatbed printing

A Steenbeck (a film -viewing or editing table) can be adapted for printing film. Negative and print stock are double loaded over the picture area while the light from the prism has been reduced with neutral density filters and a cardboard slit. Plenty of gaffer tape is also needed to make the Steenbeck light tight (the screen is also blanked out) and the 'printing' area needs to be masked as well. With a bit of trial and error the results can be very good and consistent. Suitable for mega length.

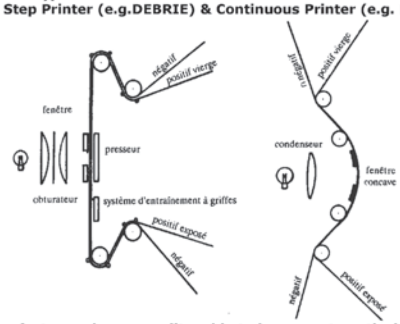


Picture synchronizer

3 Picture synchronizer

Attach (e.g. duck tape) a torch light to the synchronizer. If needed, use ND (neutral density) filters to control the amount of light. Cover the light leaks, don't worry to much about little light leaks as the home brew emulsion is not very sensitive (1–2 ASA). Double load one of the gangs with negative and unexposed film and let the machine run.

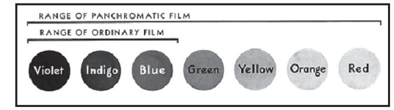
CONTACT PRINTING
two types:
Step Printer (e.g.DEBRIE) & Continuous Printer (e.g. Bell&Howell



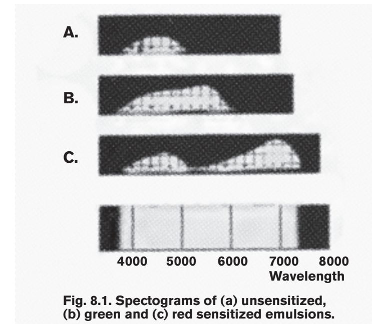
+ fast, max image quality, able to incorporate optical sound
- no special effects film format cannot change

8. CREATING COLOR (ON) FILM

As ordinarily prepared, photographic emulsions are not sensitive to red or green, their sensitivity being limited to blue and violet and to the invisible ultra-violet regions of the spectrum. In 1873, H. W. Vogel found that the addition of certain dyes to an emulsion made it sensitive approximately to the spectral region absorbed by the dye. Thus, a yellow dye sensitizes to the blue, a red dye to the green, and a blue dye to the red region of the spectrum. – *C.B. Neblette,* 1927 – 1952



Ordiary versus panchromatic film



Spectrogram unsensitized ortho panchromatic

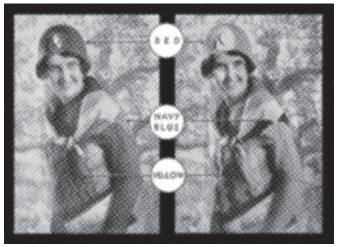
Although this booklet is about is making your own B&W emulsion and creating color by coloring the B&W emulsion, it is handy to know something about the color sensitivity of B&W emulsions. The Basic Emulsion, as made in this booklet, is so called "color-blind". There is no sensitizer added and therefor the emulsion can only be exposed by blue and violet colored light (like daylight). If you would use this home brew emulsion in a camera and expose (hypothetical as its only 1 to 4 ASA, but still possible on very sunny days) it can only see blue and violet objects. Green and red objects will stay unexposed on the film which means they will look black on the positive film image. Nowadays all B&W camera films are panchromatic and therefore sensitive to the whole color spectrum. Most B&W positive print films (stock for printing a negative to a positive) are orthochromatic: sensitive to violet, blue and green. This type of film can be used in a red dark room light without being exposed (or fogged) by the red light.

1 Basic Silver Gelatin Emulsion: unsensitized "color-blind" emulsion. Sensitive for violet and blue only.
2 Orthochromatic (green-sensitized): Sensitive to violet, blue and green. The sensitivity in the green is caused by the addition of a magenta / red dye to the emulsion, mostly erythrosin in conjunction with ammonia. If you want to do it more modern: the H.W. Sands Corp. dye SDE3008 can also be used as a green sensitizer.
3 Panchromatic (fully color-sensitized): sensitivity in the red caused by the addition of a cyan / blue dye often a representative of the cyanines. Modern style: Sands dye SDA3057 will work as a red sensitizer.

All conventional modern dyes should be added just before the final coating (mix at least 15 minutes). But… These modern dye's are very, very expensive.

16 mm still iron (direct) toning

If only I could make my own color film.
Not that I want to re-invent a commercial looking film stock. I just want to find ways to create color on film. Luckily many pioneers from the early beginnings of photography went there already. My favorites are the inventions that didn't make it commercially, or the forgotten ones and the experiments made only once as they where too time consuming. Analogue film is about time anyway and slow, very slow. So if making a home brew color emulsion film stock is a mission "impossible" for now what are the ways to obtain a sense of color on my basic B&W emulsion? All the coloring recipes included are focused on blue and green tints due to my own preference. Be careful: some of these chemicals are poisonous and very corrosive. Wear protective clothing, gloves and glasses



Panortho-ordinary

1 Tinting

Film tinting is the process of adding color to black – and – white film, usually by means of soaking the film in dye and staining the film emulsion. The effect is that all of the light shining through is filtered, so that what would be white light is, in fact, another color. All hand painted films, including the films by Méliès, are made by tinting techniques. As is the Stencil Film Technique.

Materials:

1. **Dr.Martins Bombay Inks** comes in a variety of different colors although I usually buy the basics and mix up. Mixing does not always yield the desired results, but then again, who needs precision? These are water-based paints and they come in little dropper bottles. The paint does not really chip off unless you've applied 20 layers. I usually use the clear colors, but sometimes have used the opaque colors.
2. **India Ink** also works on film, although I find that it does not always adhere to the stock. Mixing India Ink with a little household bleach will produces a thicker substance. Use a q-tip to apply to processed film. It will quickly bleach away your image. Dab it right away with a paper towel. What you'll have left is a degraded emulsion with color seeping through.
3. **Food coloring** also works well and can be mixed with a variety of substances-acts like a dye. Or try adding it to Crystal Craze. (if you can still find it at hardware stores/paint supply stores).
4. **Permanent markers**
5. **Rubber stamps** used with permanent ink
6. **Marshall Transparent Oil Paints**
7. **Powdered pigments** used to dye homemade egg tempera paint (made with egg yolk).
8. **Pebeo Gel Crystal** or **Vitrail Gel** (For painting on glass & metal. Comes in transparent, opalescent and translucent).
9. **White-out**
10. **Some graffiti brands of spray paints**
11. **Colorvir** is a magical box of toners and dyes created by French chemist *Pierre Jaffeux*. The kit is a multifaceted toning / dyeing process which can be used on all types of B&W negatives and prints. The colorvir process creates wild colors and special effects, and thus, is an experimenters dream.
It can be hard to get hold of the chemicals now, they stopped producing it years ago, but if you can get your hands on them, then the possibilities are endless.

2 Toning

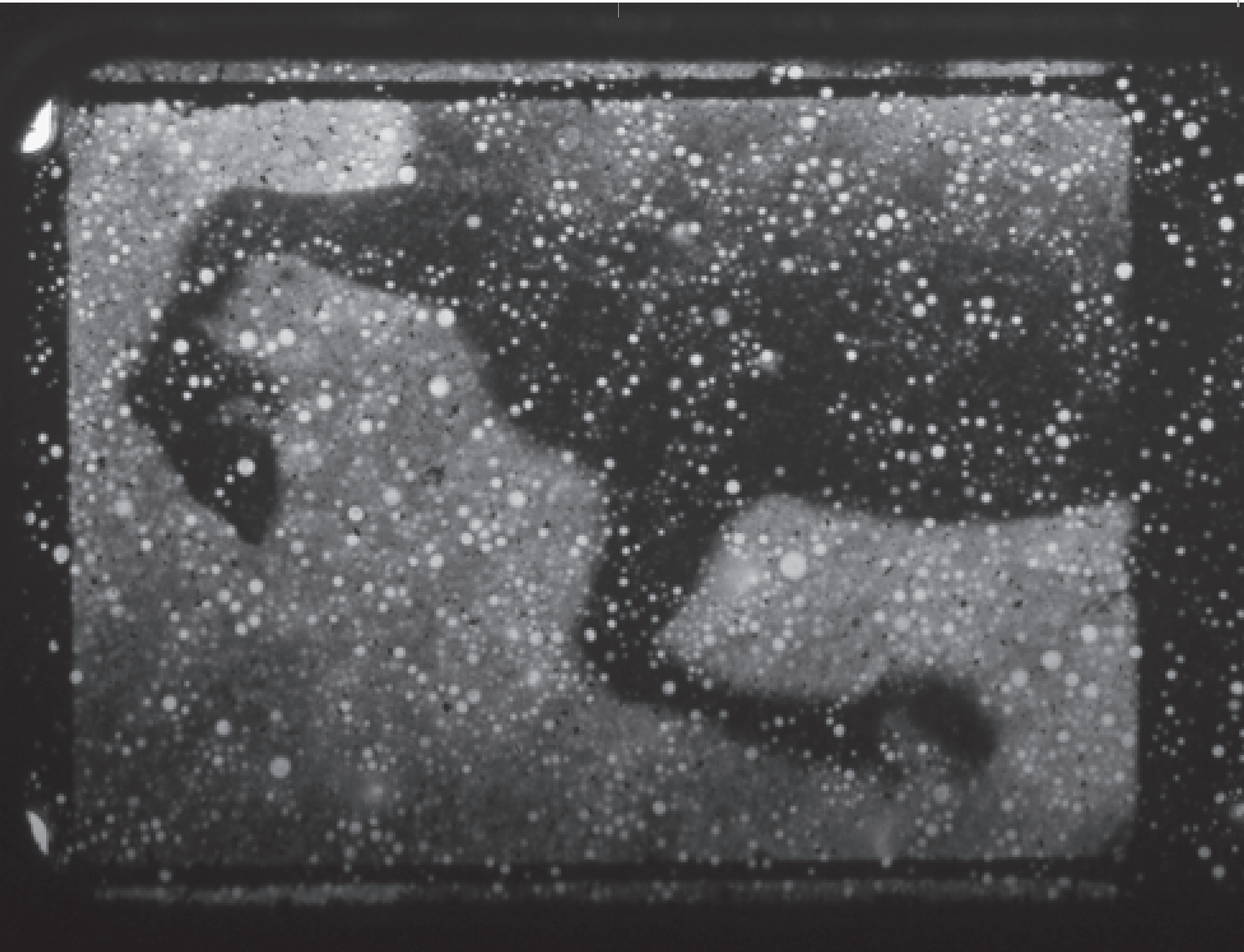
Film toning is the process of replacing the silver particles in the emulsion with colored, silver salts, by means of chemicals. There is a direct way and an indirect way. With an indirect coloring a developed and fixed image is first bleached and then dyed. A direct way is a one bath process. In both the (black) silver is replaced by color. Commonly known are the sepia and brown toning. Metal replacement toners replace the metallic silver, through a series of chemical reactions, with a ferrocyanide salt of a transition metal. Some metals, such as platinum or gold can protect the image. Others, such as iron (blue toner) or copper (red toner) may reduce the lifetime of the image.

3 Chromogen (re)developing

An other way to directly color B&W film comes from the invention of a three emulsion layered film with color couplings.
In the color process a developer agent, in combination with a color coupling, reacts on the oxidation of the silver during the developing by producing a color. This color is made synchronous on the black silver image. After development the black silver metal is bleached away, the color remains. If this color component is in the developer (and not in the emulsion) its called a chromogen developing process. The Kodachrome process is such a process. This process can also be used to color B&W film in mono colors. Although it works better with Chlorobromide emulsions than with pure Bromide emulsions like our Basic Emulsion. To get a colored result with our home brew emulsion it works best if you do the chromogen (re) developing after the original B&W developing and fixing process is done. First bleach the black silver image with (R54) Potassium ferricyanide and Potassium bromide. After this the chromogen developing process (R71 and color components R72) should be done in normal (white) light. Use a light acid stop bath (R34) and bleach the black silver metal away with the Farmer reducer (R45).

4 Early try-outs in creating color:

1. **Gaspar Color** A three color subtractive reversal print stock. It appeared in 1934 and was the first three layer color film that could be processed with minor modifications to contemporary laboratory techniques. It did not require toning, color development or use of dyes during processing. It used pre-dyed emulsions and dye bleaching. Invented by Bela Gaspar and used by Oskar Fishinger.
2. **Duplex film** was made with an emulsion on both sides. One side could be toned iron blue and the other side could be dye toned orange. Dascolor used such a system.
3. **Kinemacolor** was a system of photographing on black and white (panchromatic) film alternate frames through red and green filters at high speed – 32 frames per second – and showing at the same high frame rate on a projector with similar revolving red and green filters, special heavy duty projectors had to be manufactured.



16 mm still iron (direct) toning

Indirect DYE toning

A – Bleach-etch bath

Solution A

Copper sulphate	30 gr
Potassium citrate	50 gr
Acetic acid	30 ml
Distilleted water till	850 ml

Solution B

Ammonium thiocyanate	15 gr
Distilleted water till	150

Add solution B to A while stirring constantly. Bleach the film for 2–15 min. The longer bleached the clearer the color. Rinse short after the Bleach bath.

B – Color DYE bath

color dye (basic)	5 g
Acetic acid	15 ml
Distilleted water till	1 liter

Color dyes (basic) suitable:
rhodamine (red), auramine (yellow), malachiet-green (green), methylene blue (blue). If the clear parts of the film color as well use more Acetic acid. Coloring bath takes 1–5 min. Longer is not necessarily as the coloring stops after 10 min.

Rinse till the white parts in the film are clear again. If this doesn't not work its possible to clear the white parts by using the R69 Clearing bath shortly. If to long in this bath the color will disappear again. If the bath is working to strong, dilute with more water.

R69 – Clearing bath for bleach-etch toning

Potassium permanganate	1 g
Sulpheric Acid	2-3 drops
Water till	1 liter

An other Bleach-Etch Bath can be used with the same B: Color Dye Bath

R67 – Bleach–etch bath

Potassium ferricyanide	2,5 g
Potassium iodide	5 g
Water till	1 liter

C – Indirect Metal (iron) Toning

Bleach bath

Potassium ferricyanide	40 g
Ammonia 25%	50 ml
Water till	1 liter

Color bath

Ferric chloride	5 g
Hydrochloric acid (salt acid) 25%	20 ml
Water till	1 liter

Bleach till the black silver is yellowish. Rinse till the yellow color is gone and max. 3-5 minutes in the Color Bath. The color will just then appear during the washing following the Color Bath. (Hansma)

D – Indirect Metal (iron) Toning
(Photo technique, P. Carpentier 1967)

Bleach bath

Potassium ferricyanide	20 g
Water till	1 liter

Bleach till a grey-white image. Wash for 5-10 minutes. According Agfa (recipe 263) the image then can be colored in the following solutions. Leave in the Color Bath till the image doesn't change anymore. Rinse well afterwards. The Color bath solutions can be mixed for olive green tones.

Color bath green

Ferric chloride	20 g
Potassium bromide	10 g
Oxalic acid	10 g
Water till	1 liter

Color bath blue/green

Ferric oxalate	20 g
Potassium bromide	10 g
Oxalic acid	10 g
Water till	1 liter

Direct DYE toning

E – Direct Metal (iron) Toning
(B. Hanlo, 1996)

Blue

potassium ferricyanide	4 g
ferric chloride	4 g
citric acid	4 g
water till	1 liter

Green / blue

Potassium ferricyanide	4 g
Ammonium ferric citrate	6 g
Acetic acid	20 ml
Water till	1 liter

Leave in the Color Toning Bath till the desired color appears. Rinse shortly after. If rinsed to long the color will get less intense.

And other:
F – Direct Metal (iron) Toning
(E. Vogel 1935)

Blue

Potassium ferricyanide	4 g
Ferric ammonium citrate (green)	4 g
Citric acid	6 g
Water till	1 liter

Leave in the Color Toning Bath till the desired color appears. Rinse shortly after. If rinsed to long the color will get less intense.The Iron Toning component is Ferric ammonium citrate (green) or even better with Ferric ammonium oxalate (C6H12FeN3O12). The latter gives a deeper blue coloring and better exposure quality.

Chromogen Recipes

R54 – Bleach bath previous to Chromogen (re)developing

Solution A

Potassium ferricyanide	100 g
Water till	1 liter

Solution B

Potassium bromide	100 g
Water till	1 liter

for use mix 1 part A + 1 part B

R71 – Chromogenic developer
(Helfficher 1967)

Diethyl-p-phenylene-diamine hydrochloride	2 g*
Sodium carbonate	30 or 80 g
Sodium Sulfite	1 g
Potassium bromide	1 g
Hydroxylamine hydrochloride	1 g
Water till	1 l

**(this is Genochrome or Activol)*

R72 – Color Couplers
(Helfficher 1967)

Magenta

p-nitrophenyl acetanilide	0,5 g
Acetone	12 ml
Ethanol (denatured)	100 ml

Brown

2,5-dichloroaceto-acetanilide	0,5 g
p-nitrophenyl acetonitrile	0,5 g
Acetone	12 ml
Ethanol (denatured)	100 ml

Blue

Alpha-napthol	0,7 g
Alcohol or Methyl Alcohol	100 ml

Cyan

Dichloro alpha-napthol	1 g
Alcohol or Methyl Alcohol	100 ml

Cyan

2,4-dichloro-alpha-napthol	1 g
Alcohol or Methyl Alcohol	100 ml

Green

2,4-dichloro-alpha-napthol	0,5 mg
2,5-dichloro acetoacetanilide	0,5 mg
Alcohol or Methyl Alcohol	100 ml

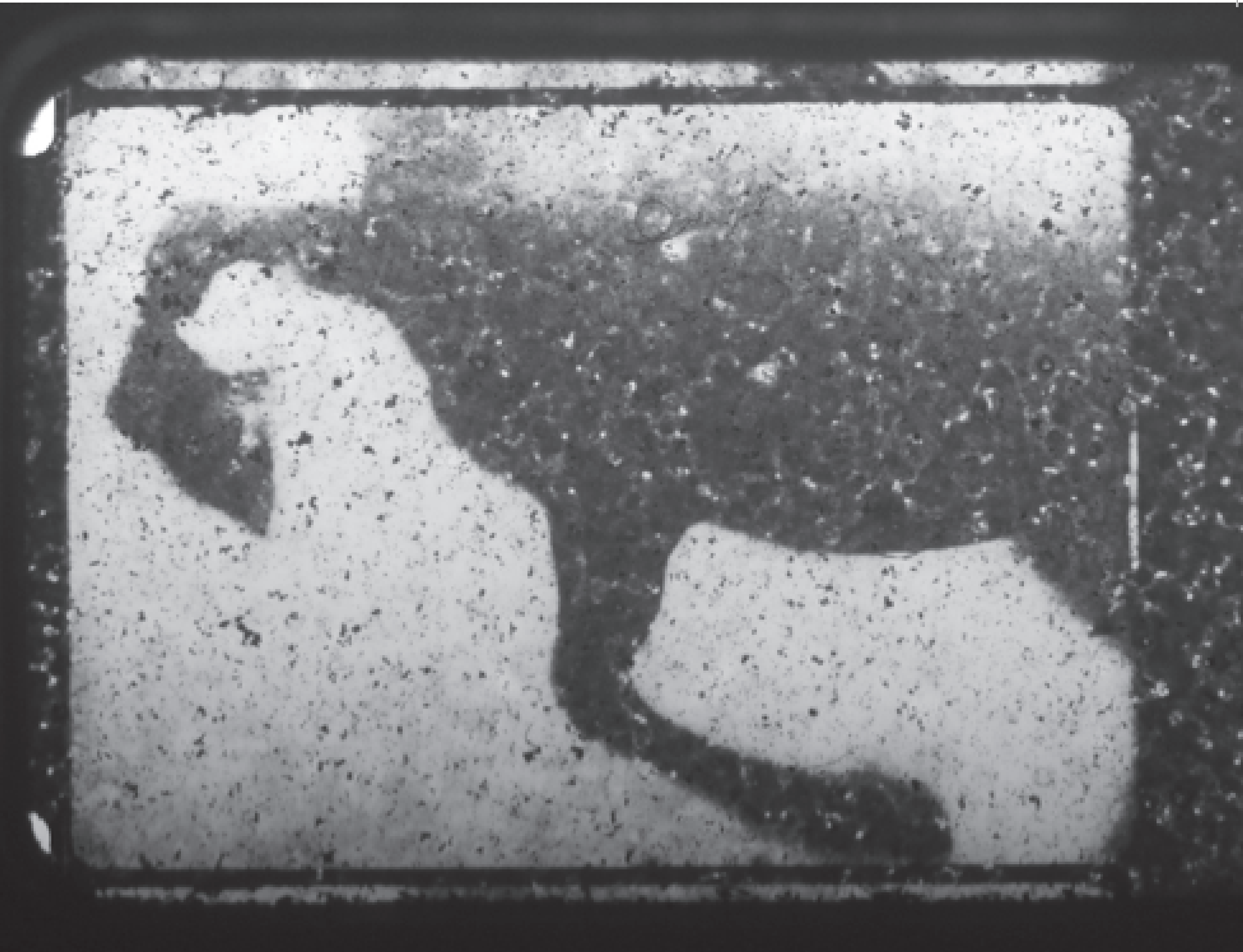
Yellow

o-chloroaceotanilide	1 g
Alcohol or Methyl Alcoho	100 ml

Yellow

2,5-dichloro acetanilide	1 g
Alcohol or Methyl Alcohol	100 ml

For use, mix 10 parts of *R71 developer* with 1 part of *R72 coupler*.
The developer has a very short live and can only be used ones. So mix shortly before use



16 mm still methyleen blue (indirect) toning

Chromogen Recipes

R34 – Stop bath for Chromogen (re)developing

Acetic acid	15-20 ml
Water till	1 liter

R45 – Farmer reducer

Solution A

Sodium thiosulfate	100 g
Water till	1 liter

Solution B

Potassium ferricyanide	100 g
Water till	1 liter

Add just before use 100 ml A + 6 ml B + 100 ml water. This Solution has a life time of 15 to 30 minutes.

Colored emulsions by developing
(Baker 1941)
It should be pointed out, without refined facilities for both coating and processing, that only comparatively crude experiments can be envisaged with monopacks.
Although it is beyond the scope of this book to enter into the manufacture of emulsions containing color formers, the following formulas for producing colored images by direct development of silver bromide emulsions may be given.

A basic developer is used as follows

Sodium carbonate	40 g
Sodium sulphite	20 g
2-amino-5-diethyl aminotoluene hydro-chloride	0.5 g
2 % potassium bromide	30 cc
water	1000 cc

The blue-green coupler

2-4-dichloro-1-naphthol	1 g
Acetone	5 cc
Basic developer	250 cc

The magenta coupler

P-nitrophenyl-acetonitrile	0.05 g
Acetone	5 cc
Basic developer	250 cc

The yellow coupler

Aceto acetanilide	0.5 g
Acetone	5 cc
Basic developer	250 cc

The image is formed in color on development with the above solutions, and is afterwards fixed in plain hypo solution. The reduced silver is then removed by treatment with hypo-ferricyanide when the clear dye images are left.

G — Colored emulsions by developing
by Tull

Chromogenic developer by Tull

Diaethyl- or Dimethyl-para-phenyleendiamine	1 g
Sodium sulfite	5 g
Potassium carbonate	20 g
Color Coupler solution	100 ml
Water till	1 liter

Color Coupler Solutions

Blue

A-naphtol	0,7 g
Alcohol 96%	100 ml

Cyan

Dichloor-a-naphtol	1 g
Methyl alcohol 96%	100 ml

Green

Dichloororthocresol	0,9 g
Alcohol 96%	100 ml

Yellow

Orthochloro-acetoaceetanilide	1 g
Alcohol 96%	100 ml

Magenta

Paranitrophenyl-acetonitril	8 g
Alcohol 96%	100 ml

Bleach Bath

Potassium ferricyanide	25 g
Potassium bromide	12 g
Water till	1 liter

Neutral Fix Bath

Sodium thiosulfate	200 g
Water till	1 liter

Prepare short before use as the solution can only be kept for 2 hours. Developer time at 20C-68F is 15-20 minutes. Afterwards rinse for 5 min. Bleach the Silver image in the Bleach Bath and rinse again for 5 min. Fix in a 20% neutral Sodium thiosulfate solution. Rinse well and dry.

9. HAPPY MISTAKES

What is most exciting about this type of filmmaking is not knowing exactly what will result. One then needs the lyrical, musical and cinematic taste to sculpt the result into a film which best demonstrates, exploits and celebrates the results of the experiments. If you stick with good ingredients you will inevitably have happy results. Then again, not all experiments work but what you learn there can often be employed in a new direction or experiment to actually work. It's also very important to have fun in and a love of the process. *Jeff Scher*, 2004

1 Reticulation

A relief pattern that can appear in the gelatin part of an emulsion. Especially in non hardened emulsions. Reticulation is the distortion of the emulsion layer of a film, caused when it is taken from one bath to another that has a dramatic difference in temperature. If for example you take the film from a warm developer to a cold fixer or from a warm fixer to a freezing wash the film may reticulate. This is because the sudden and dramatic change in temperature forces the emulsion to expand or contract causing grain to cluster together into larger collections.

With today's modern film emulsions it is very difficult to create reticulation, because manufacturers have gone to great lengths to produce better quality emulsions that can withstand sudden changes in temperature. But what about our home brew emulsion?

2 Solarisation

The Solarisation or Sabatier effect originates from a darkroom technique commonly associated with the photographer/artist Man Ray, who perfected the technique and made it popular among photographers. By fogging/giving light to a black and white print during mid development, one could achieve a partial reversal of some of the tones and end up with a mixture of positive and negative tones in the final print. If you want to solarize your own image it is best to use a slightly "aged" developer. During the negative developing process, so developing and fixing only, quickly shine a light within the 30's – 45's sec. of putting it in the developer. You will never produce a same effect or look twice. Try and error, and have fun.

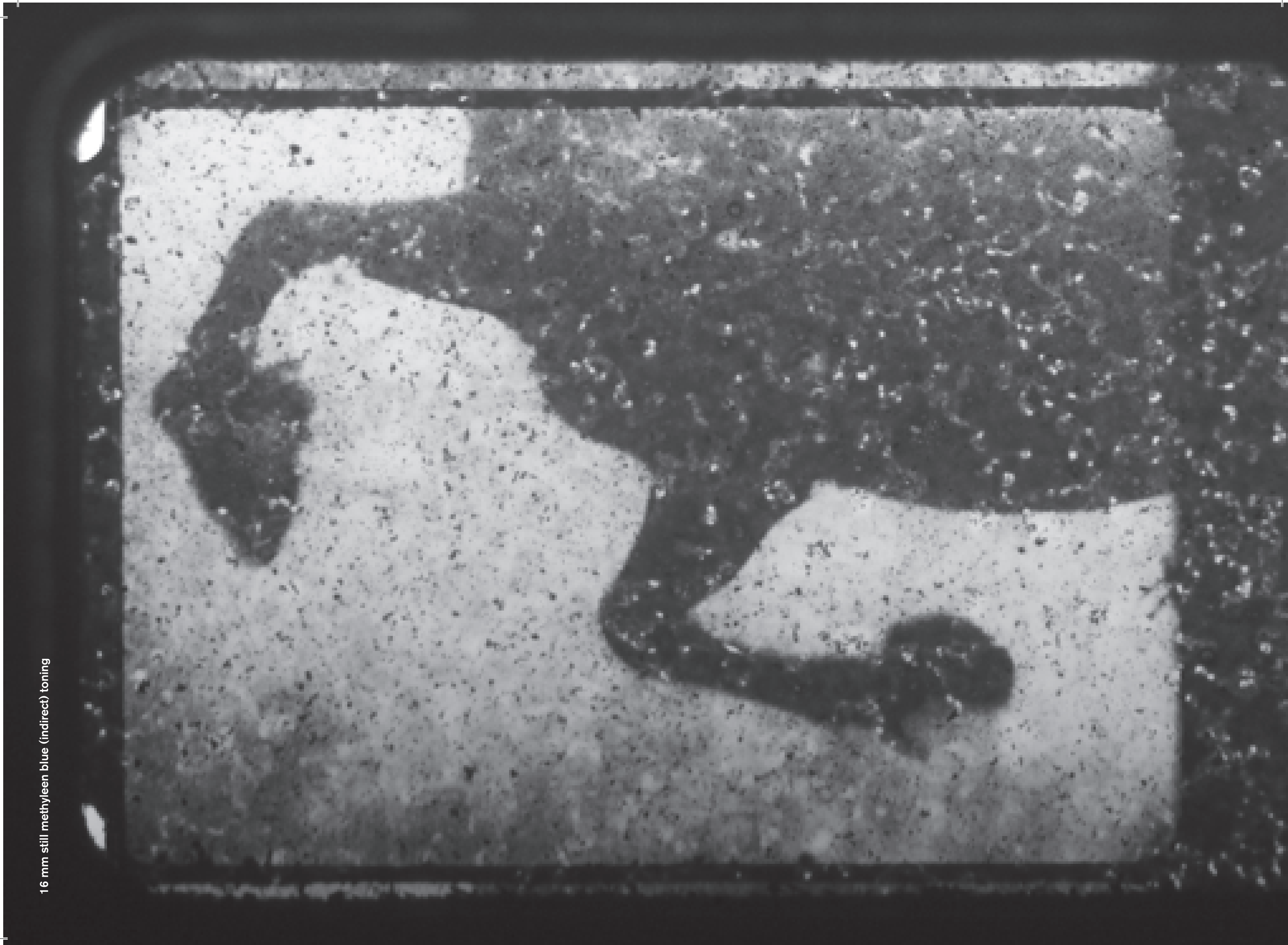
3 Caffenol

(B&W developing with instant coffee)

Caffenol is a B&W developer that is made out of household ingredients that can be bought in a drugstore and/or supermarket:

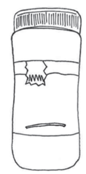
Instant Coffee (with caffein)
Washing Soda
Vitamin C (powder)

The origins of Caffenol are not quite clear, but it is said that it was used / (invented?) during WWII as supplies of photographic chemicals where short. Although it sounds very environmentally friendly its not any "cleaner" than most other B&W developers. It just means we have more chemistry in our kitchen cupboards then we are aware of. So i also developed my home brew emulsion with the basic



16 mm still methyleen blue (indirect) toning

Caffenol recipe. Although risky due to the long developing time and the softness of the emulsion. The B&W image was okay but the clear parts in the image were of a strong golden yellow. Quite beautiful actually but not there on purpose. For a split second I thought I invented a way of double coloring my film. Tinting the clear parts in golden yellow due to the Caffenol developing process and afterwards toning the black silver image into blue with a direct Iron Toning recipe. Unfortunately the yellow color disappeared in the Iron Toner bath. The black silver image got blue though.


Instant Coffee

Recipes Caffenol-C-M, C-H, C-L

by imagesfrugales 2010: http://caffenol.blogspot.com

	Caffenol-C-M	Caffenol-C-H	Caffenol-C-L
Washing Soda, waterfree	54 g/l	54 g/l	16 g/l
Vitamin-C	16 g/l	16 g/l	10 g/l
Potassium Bromide Kbr	-	1 g/l	1(-2) g/l*
Instant Coffee	40g/l	40 g/l	40 g/l
Use for	Low to medium speed film up to 100 ASA, speed enhancing use push 1 or 2 as starting point.	General purpose, speed enhancing, low fog.	General purpose, speed enhancing, stand-development, low pH, low fog, small grain, high acctuance.
Time 20°C	15 minutes as a starting point.	15 minutes as a starting point.	70 minutes as a starting point.
Agitation	Standard, 10 times initially, 3 times every minute.	Standard, 10 times initially, 3 times every minute.	10 gentle turns initially, then let stand.
Remarks	Easy to brew, easy to get, quite foolproof.	-	*Use more than 1 g/l only if you get uneven development. Presoak 5 minutes. Simply the best!

General remarks > HAVE FUN!!!
Coffee needs a couple of minutes for proper diluting.
Don't store the mix.
Add agents in given order.
Use demineralized water if in doubt.
Adjust times for different temperatures.
Check temperature after diluting the soda.
Standard international units used,
recalculate for your preferred units.
Measure with accuracyespecially Caffenol-C-L.

Washing Soda


Vitamin C

10. CHEMISTRY USED

A **Acetic acid 99-100% *(CH3COOH)***
It is a colorless liquid that when undiluted is also called Glacial Acetic Acid. Acetic acid is the main component of vinegar (apart from water; vinegar is roughly 8% acetic acid by volume). Although it is classified as a weak acid, concentrated acetic acid is corrosive and attacks the skin. Solutions of 2% of Acetic acid are used as stop bath or to remove (calc) drying spots from negative. Glacial acetic acid is also used in film coloring toners.

Ammonia solution *(NH4OH)*
also known as Ammonia hydroxide. It is a solution of ammonia (NH3) in water. Ammonia is a colorless gas with a characteristic pungent smell. Like many amines, it gives a deep blue coloration with copper(II) solutions. Ammonia solution can dissolve silver oxide residues.

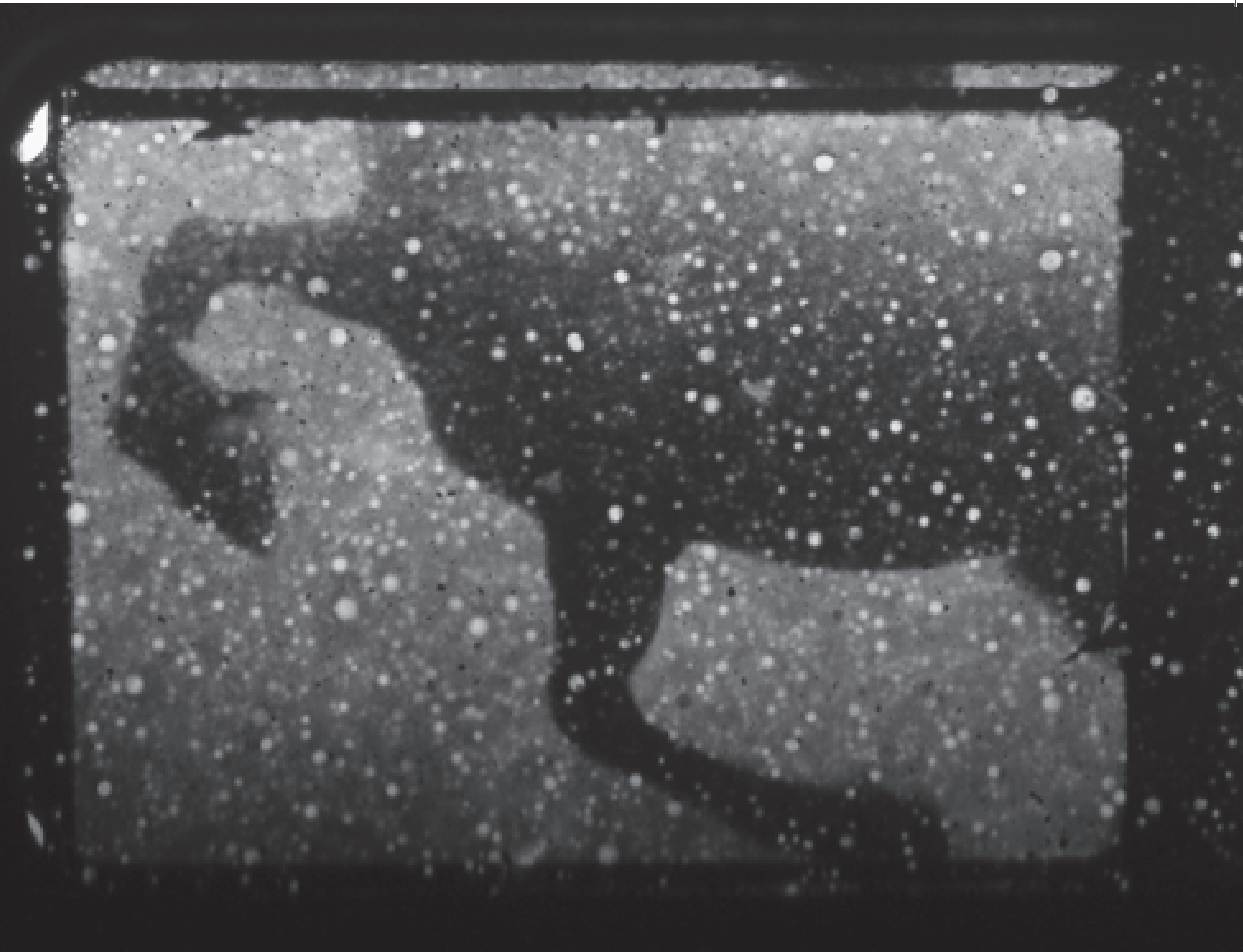
Ammonium ferric citrate *(C6H8O7.xFe.xNH3)*
Other names Ferric ammonium citrate; Ammonium Iron(III) Citrate; Iron ammonium citrate. It is a green or reddish-brown powder which is very soluble in water. Its a compound of ferri, ammonium and citric acid. A food additive with E number E381. Used in iron-toning solutions. Occurs also as brown scales, but green scales are preferred for photographic purposes. Both brown and green scales are light-sensitive. Keep well closed and protected from light. For toning Ferric ammonium citrate (green) can be replaced by ferric ammonium oxalate (C6H12FeN3O12). The latter gives a deeper blue coloring and better exposure quality.

Ammonium thiocyanate or Ammonium rhodanide *(NH4CNS)*
used as a stabilizing agent in photography. Also used as part in coloring (bleach-etch process) and fixer bath. Can produce poisoned gas in combination with acids.

B **Boric acid *(H3BO3)***
Also called hydrogen borate, boracic acid, orthoboric acid and acidum boricum. It exists in the form of colorless crystals or a white powder that dissolves in water. Boric acid is poisonous if taken internally or inhaled in large quantities. It is used in fix as a buffer agent. A buffer solution is water mixed with a chemical to give it special properties in regards to pH (acidity). The chemical, known as a buffer agent, resists pH changes when exposed to acids and bases when properly mixed in a solution.

C **Citric acid *(C6H8O7)***
At room temperature, citric acid is a white crystalline powder. Citric acid can be used as a lower-odor stop bath as part of the process for developing photographic film. Photographic developers are alkaline, so a mild acid is used to neutralize and stop their action quickly, but commonly used acetic acid leaves a strong vinegar odor in the darkroom. It is also used in film coloring toners.

Copper sulphate *(CuSO4·5H2O)*
Also known as blue vitriol, this substance was made by the reaction of sulfuric acid on elemental copper. The bright-blue crystals are soluble in water and alcohol. The most common application for copper sulfate was combining it with potassium bromide for making copper bromide bleach for intensification and toning. Its very toxic to the environment, irritating to the eyes and skin, and also can be harmful if swallowed.



16 mm still caffenol

F Ferric ammonium citrate (green) or ammonium iron(III) citrate
It is used as a reducing agent of metal salts of low activity like silver and is also in a commonly used recipe with potassium ferricyanide to make cyanotype blue prints. See Ammonium ferric citrate.

Ferric chloride also called iron(III) chloride *(FeCl3)*
The color of iron(III) chloride crystals depends on the viewing angle: by reflected light the crystals appear dark green, but by transmitted light they appear purple-red. Iron(III) chloride is toxic, highly corrosive and acidic. The anhydrous material is a powerful dehydrating agent. Used in photographic color toners and for etching gravure plates.

Ferric oxalate also known as iron(III) oxalate *(Fe2(C2O4)3)*
It can be used to reduce the compounds of silver metal to the metallic state. In these methods, substances are used that form colored insoluble pigments with the iron. Ferric oxalate and ammonium ferric oxalate are light-sensitive iron(III) salts that can be used in the sensitizer. Harmful when in contact with skin and inhalation.

H Hydrochloric acid
is a clear, colorless solution of hydrogen chloride (HCl) in water. It is a highly corrosive, strong mineral acid. Hydrochloric acid was known to European alchemists as spirits of salt or acidum salis (salt acid). Both names are still used, especially in non-English languages. Historically hydrochloric acid was produced from vitriol (sulfuric acid) and common salt. It first appeared during the Renaissance. The solution has a corrosive effect on human tissue, potentially causing irreversible damage to respiratory organs, eyes, skin, and intestines. Upon mixing hydrochloric acid with common oxidizing chemicals, such as sodium hypochlorite (bleach, NaClO) or potassium permanganate (KMnO4), the toxic gas chlorine is produced.

Hydroquinone *(C6H4(OH)2)*
It is a white granular solid. It is a major component in most photographic developers for film and paper where, with the compound Metol, it reduces silver halides to elemental silver. Dangerous to the the environment and avoid all contact with skin, eyes and by inhalation.

Hydroxylammonium chloride *(HONH2·HCl)*
Another name for Hydroxylamine hydrochloride. White solid crystalline. Is used as a color stabilizer and emulsion additive in color films. Harmful, irritating and dangerous to the environment.

M Metol *((C7H10NO)2SO4)*
is the chemical compound with the name monomethyl-p-aminophenol hemisulfate. In its pure form, it is a solid, rather light-sensitive chemical. Other names N-methyl-p-aminophenol sulfate, p-(methylamino)phenol sulfate, monomethyl-p-aminophenol hemisulfate, Elon (Kodak), Rhodol, Enel, Viterol, Scalol, Genol, Satrapol. It is a developing agent used in black & white photographic developers.

O Oxalic acid *(H2C2O4)*
is an organic compound; it is a colorless crystalline solid that dissolves in water to give colorless solutions. In terms of acid strength, it is much stronger than acetic acid. Oxalic acid is a reducing agent. Oxalic acid is used as a mordant in dyeing processes and also used in bleaches. Its presence makes it dangerous to eat unripe carambola or monstera

fruits. Members of the spinach family are high in oxalates, as is sorrel. Rhubarb leaves contain about 0.5% oxalic acid.

P Potassium alum *KAl(SO4)2*
white small crystals. It is used as a hardener for photographic emulsions (films and papers), usually as part of the fixer, although modern materials are adequately hardened and this practice has fallen out of favor. But it could be wise to use for the home brew emulsion.

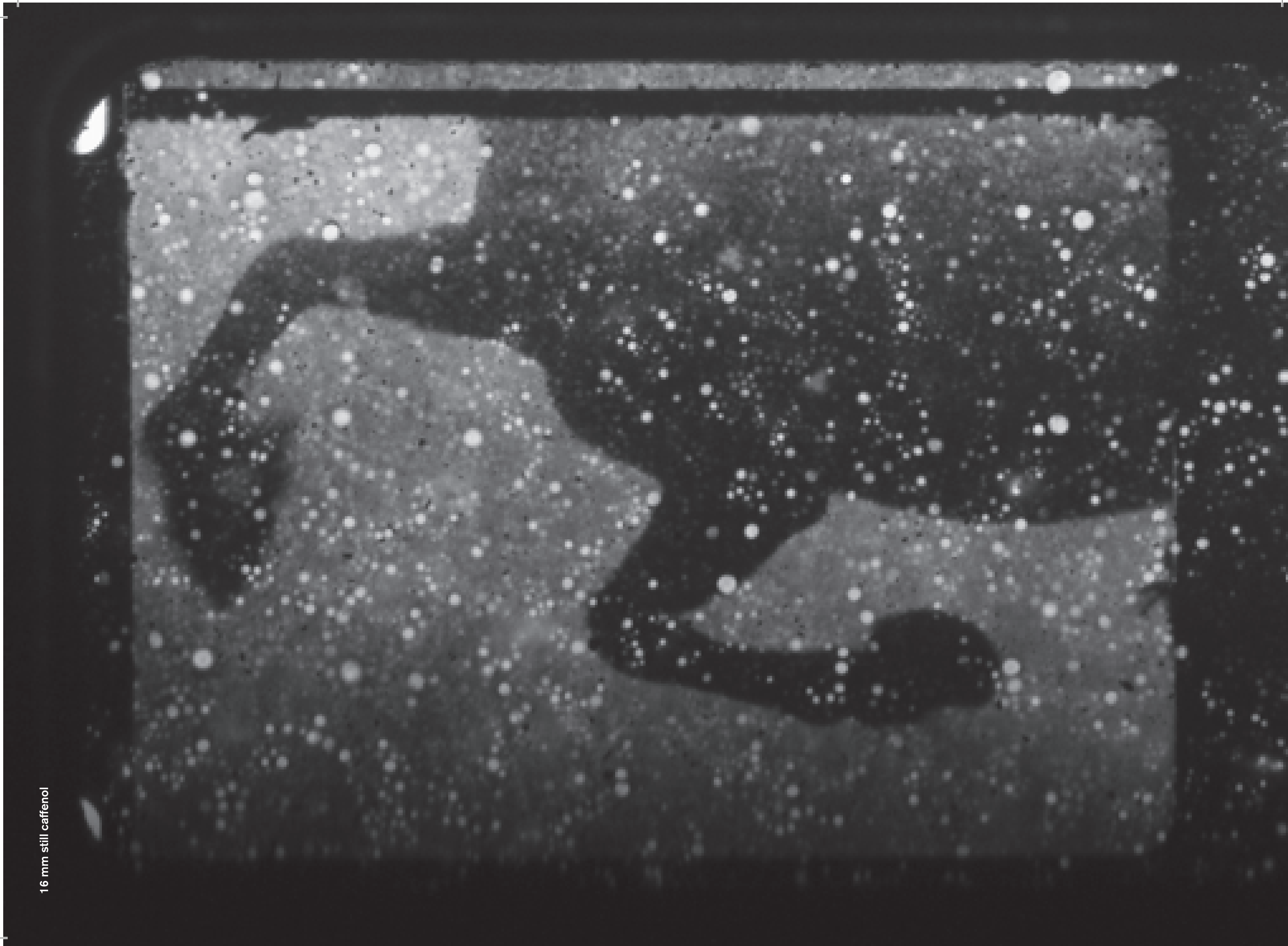
Potassium bromide *(KBr)*
is a salt. A white/grey crystalline powder, soluble in water. In addition to manufacture of silver bromide, potassium bromide is used as a restrainer in black and white developer formulas.
It improves differentiation between exposed and unexposed crystals of silver halide, and thus reduces fog.

Potassium carbonate *(K2CO3)*
Other names are Potash or Pearl Ash.
It is a white salt, soluble in water (insoluble in ethanol). A highly soluble alkaline accelerator used in most developing solutions. All developing agents (not developing solutions) are either neutral or slightly acid. Most developing agents must be in an alkaline state to be effective reducing agents, thus solutions require an alkali to activate the developing agent. A developing solution contains an accelerator so the solution becomes alkaline. Without an accelerator, there is little or no action. An other common used accelerator is sodium carbonate.

Potassium citrate *(C6H5K3O7.H2O)*
Transparent crystals or white, granular powder. Very soluble in water, insoluble in ethanol. Chemical used in blue and green toners.

Potassium ferricyanide *(K3[Fe(CN)6])*
Bright red salt. It is soluble in water and its solution shows some green-yellow fluorescence and is not containable.
The compound has widespread use in blueprint drawing and in photography (Cyanotype process). Iron and copper toning involve the use of potassium ferricyanide. Potassium ferricyanide is used as an oxidizing agent to remove silver from negatives and positives, a process called dot etching. In color photography, potassium ferricyanide is used to reduce the size of color dots without reducing their number, as a kind of manual color correction.
It is also used in black-and-white photography with sodium thiosulfate (hypo) to reduce the density of a negative or gelatin silver print where the mixture is known as Farmer's reducer; this can help offset problems from overexposure of the negative, or brighten the highlights in the print.
Potassium ferricyanide has very low toxicity, its main hazard being that it is a mild irritant to the eyes and skin. However, under very strongly acidic conditions, highly toxic hydrogen cyanide gas is evolved. Other names Potassium hexacyanoferrate(III), Prussian red.

Potassium iodide *(KI)*
White salt. It absorbs water less readily. Aged and impure samples are yellow because of aerial oxidation. Potassium iodide is a mild irritant and should be handled with gloves.
KI is a precursor to silver iodide (AgI) an important chemical in film photography. The use of iodide to gelatin-bromide emulsions makes a higher degree of digestion possible without the danger of fog and leads to emulsions of higher sensitivity + brighter negatives with higher contrast and density + shift



16 mm still caffenol

in spectral sensitiveness towards the longer wave-lengths.

Potassium permanganate *($KMnO_4$)*
Dark purplish–bronze–gray needles, magenta–rose in solution. Formerly known as permanganate of potash or Condy's crystals. It dissolves in water to give intensely pink or purple solutions. Keep in dark brown glass bottles otherwise it will decompose. It is a strong oxidizing agent especially in acid solutions. Weak Sulpheric acid permangenate solutions oxidate silver into silver sulfate. Potassium permanganate is also used to remove / bleach a black silver image in a reversal process. By adding Sodium chloride or Potassium bromide the oxidated silver is reduced to silver chloride or silver bromide. Very corrosive. Avoid any contact with skin and eyes. Reacts highly explosive with concentrated sulfuric acid. When solid permanganate is mixed with pure glycerol or other simple alcohols it will result in a violent combustion reaction.

S

Silver Nitrate *($AgNO_3$)*
A chemical compound prepared by the reaction of nitric acid with silver, and purified by re-crystallization. A colorless crystalline material that is very soluble in water. It is darkened by sunlight or contact with organic matter such as the skin. Silver Nitrate forms with one of the halogens (bromide, chloride, iodide) a light-sensitive chemical. Taken internally silver nitrate is a poison.

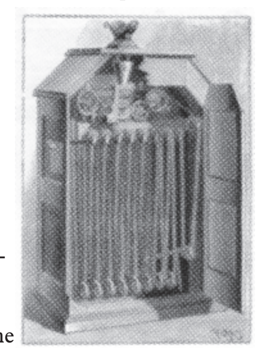
Sodium carbonate *(Na_2CO_3)*
Other name Washing Soda. In monohydrate form a white powder. Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation (lung irritant). Sodium carbonate is used as an accelerator, as a pH regulator to maintain stable alkaline conditions necessary for the action of the majority of photographic film developing agents. See also Potassium carbonate.

Sodium sulfite *(Na_2SO_3)*
Other name is Hypo clear. Colorless crystals or white powder. In photography it is used to protect developer solutions from oxidation and (as hypo clear solution) to wash fixer (sodium thiosulfate) from film and photo-paper emulsions. Also used as clear bath in B&W reversal process. The anhydrous form is much more stable against oxidation by air.

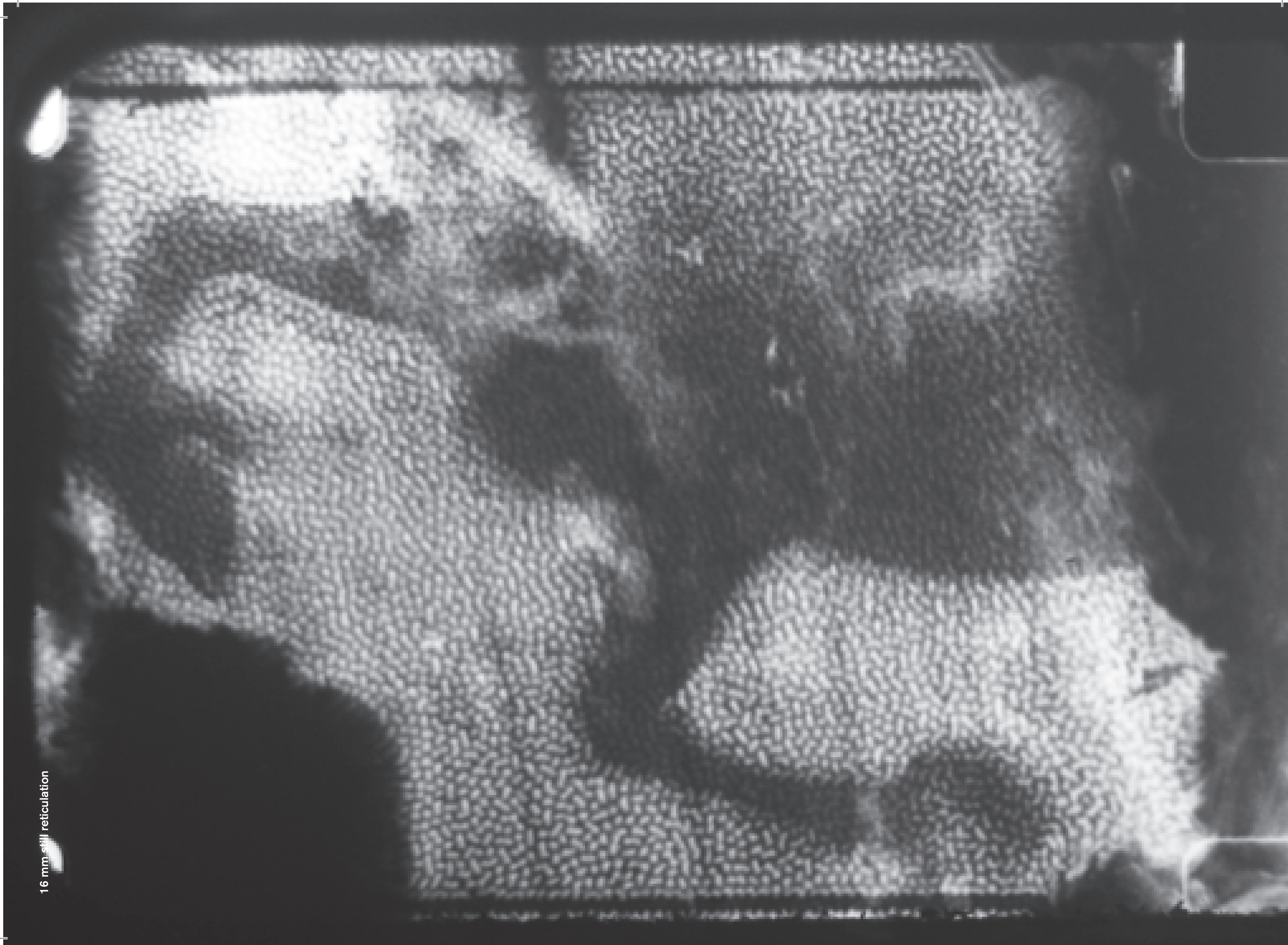
Sodium thiosulfate *($Na_2S_2O_3$)*
Other names Sodium hyposulfite and Hyposulphite of soda. A colorless crystalline compound. Silver halides, e.g. AgBr, a typical components of photographic emulsions, dissolve upon treatment with aqueous thiosulfate. In this application to photographic processing, discovered by John Herschel and used for both film and photographic paper processing, the sodium thiosulfate is known as a photographic fixer, and is often referred to as hypo, from the original chemical name, hyposulphite of soda.

11. A BRIEF HISTORY

1727 — Johann H. Schulze, a German physicist, discovers that silver salts turn dark when exposed to light.
1780 — Carl Scheele, a Swedish chemist, shows that the changes in the color of the silver salts could be made permanent through the use of chemicals
1826 — J.N.Niépce produces the world's first known photograph with a pewter plate coated with bitumen of Judea, a mixture similar to asphalt. Exposure time (outside in full sun) was 8 hours
1830s — Louis Daguerre, a French inventor, develops the first practical method of photography by placing a sheet of silver-coated copper treated with crystals of iodine inside a camera and exposing it to an image for 5 to 40 minutes. Vapors from heated mercury developed the image and sodium thiosulfate made the image permanent.
1839 — A British inventor, William H. Fox Talbot, an English classical archaeologist, made paper sensitive to light by bathing it in a solution of salt and silver nitrate. The silver turned dark when exposed to light and created a negative, which could be used to print positives on other sheets of light sensitive paper.
1851 — The British photographer Frederick S. Archer develops a photographic process using a glass plate coated with a mixture of silver salts and an emulsion made of collodion. Because the collodion had to remain moist during exposure and developing, photographers had to process the pictures immediately.
1871 — English physician and amateur photographer Richard Leach Maddox invented the dry gelatin photographic emulsion plate process. It was these origins that led to the miniaturization and adaptability of photographic emulsions, and consequently paved the way for social and action photography and cinematography.
1878 — Edward Muybridge known for his pioneering work on animal locomotion which used multiple cameras to capture motion in stop-action photographs, and his *zoopraxiscope*, a device for projecting motion pictures that pre-dated the flexible perforated film strip used in cinematography.
1878 — The longer the emulsion was heated, the more sensitive it became. The cause, called ripening, was first identified by Sir Joseph Wilson Swan.
1882 — In France, Etienne Marey develops a camera—shaped like a gun—that can take twelve pictures per second.
1884 — George Eastman formed the Eastman Dry Plate & Film Company.Eastman and William H. Walker introduces film made on a paper base instead of glass, wound in a roll, eliminating the need for glass plates.
1884 — H.W.Vogel creates the first panchromatic emulsion (*azalineplates*).
1887 — Hannibal Goodwin patented a method for making transparent, flexible roll film out of nitrocellulose film base, which was used in Thomas Edison's *Kinetoscope*, an early machine for viewing animation.


Kinetoscope

1888 — The name Eastman "Kodak" Co. was born and the KODAK camera was placed on the market, with the slogan, "You press the button - we do the rest."



16 mm still reticulation

1891–1894 — Thomas Edison and W.K. Dickson develop and patented the *Kinetoscope*, a motion picture exhibition device that introduced the basic approach that would become the standard for all cinematic projection by creating the illusion of movement by conveying a strip of perforated film bearing sequential images over a light source with a high-speed shutter.

1895 — Auguste en Louis Lumière invented cinematography. The two French brothers patent a combination movie camera and projector: The *cinématographe*. The first footage ever to be recorded using it was recorded on March 19, 1895. This first film shows workers leaving the Lumière factory.

1907 — Homolka discovers that certain dyes such as indoxyl and thio-indoxyl develop a colored image, along with the silver metallic black, which are not soluble in water. After bleaching away the silver metalic a colored image remains: the birth of chromogen developing

1919 — De Forest patented his sound-on-film—*Phonofilm*—process, which improved on the work of Finnish inventor Eric Tigerstedt and the German partnership Tri-Ergon. *Phonofilm* recorded sound directly onto film as parallel lines of variable shades of gray, which later became known as a “variable density” system as opposed to “variable area” systems. Optical sound tracks are visual renditions of sound wave forms and provide sound through a light beam and optical sensor within the projector.

Phonofilm reel

1923 — Kodak introduces a 16 mm reversal film on cellulose acetate (safety) base, the first 16 mm *CINE-KODAK Motion Picture Camera*, and the *KODASCOPE Projector*.

1932 — The first 8 mm amateur motion-picture film, cameras, and projectors were introduced.

1948 — Ansel Adams formulated his findings on the *Zone System*: An approach to a standardized way of working that guarantees a correct exposure in every situation, even in the trickiest lighting conditions such as back lighting, extreme difference between light and shadow areas of a scene, and many similar conditions that are most likely going to throw off your camera’s metering giving you a completely incorrect exposure.

2012 — Following the demise of *Kodachrome*, Kodak has stopped the production (after 77 years) of all its other color reversal films. The company said that the move was due to dropping customer demand and complex manufacturing issues, and has essentially left Fujifilm as the sole remaining player in the market. The first color reversal, or slide, film (Kodachrome) was manufactured in 1935. At first as a cine-film, later also for photographic use.

2013 — Fujifilm has stopped its production of *Motion Picture Film* products by March, 2013.

View from the window at le Gras, J.N.Niépce

12. LINKS, BOOKS & PAPERS

thelightfarm.com

handmadefilm.org

unblinkingeye.com/Articles/Emulsion/emulsion.html

brianpritchard.com

filmlabs.org

Emulsions and Coating with Ron Mowrey: http://www.youtube.com/watch?v=i4q0Ryh9pBE

zauberklang.ch/colorsys.php

dwrphotos.com/blog/EmulsionResearch.htm

firstcall-photographic.co.uk/categories/28/b-w-toner-chemicals?perpage=ALL

Scribd.com/doc/130834332/Photographic-Emulsion-Technique

Books & papers

1 *Photographic Emulsion Technique* / T. Thorne Baker (1941 and 1948)

2 *Photographic Emulsions* / E.J. Wall (1929)

3 *Photographic Notebook* / Dr. E. Vogel (1935)

4 *The Negative* / Ansel Adams (1948)

5 *Dark Room Recipes* / D. Helfferich (1975)

6 *Photography: Its Materials and Processes, Handbook of Photography and Reprography*, *Photography: Principles and Practices* / C.B. Neblette (1927-1952)

7 *The Photographic Emulsion* / B.H. Carroll, D. Hubbard, & C.M. Kretschman

8 *Photo Chemicals and Recipes* / J.J. Hansma (1956)

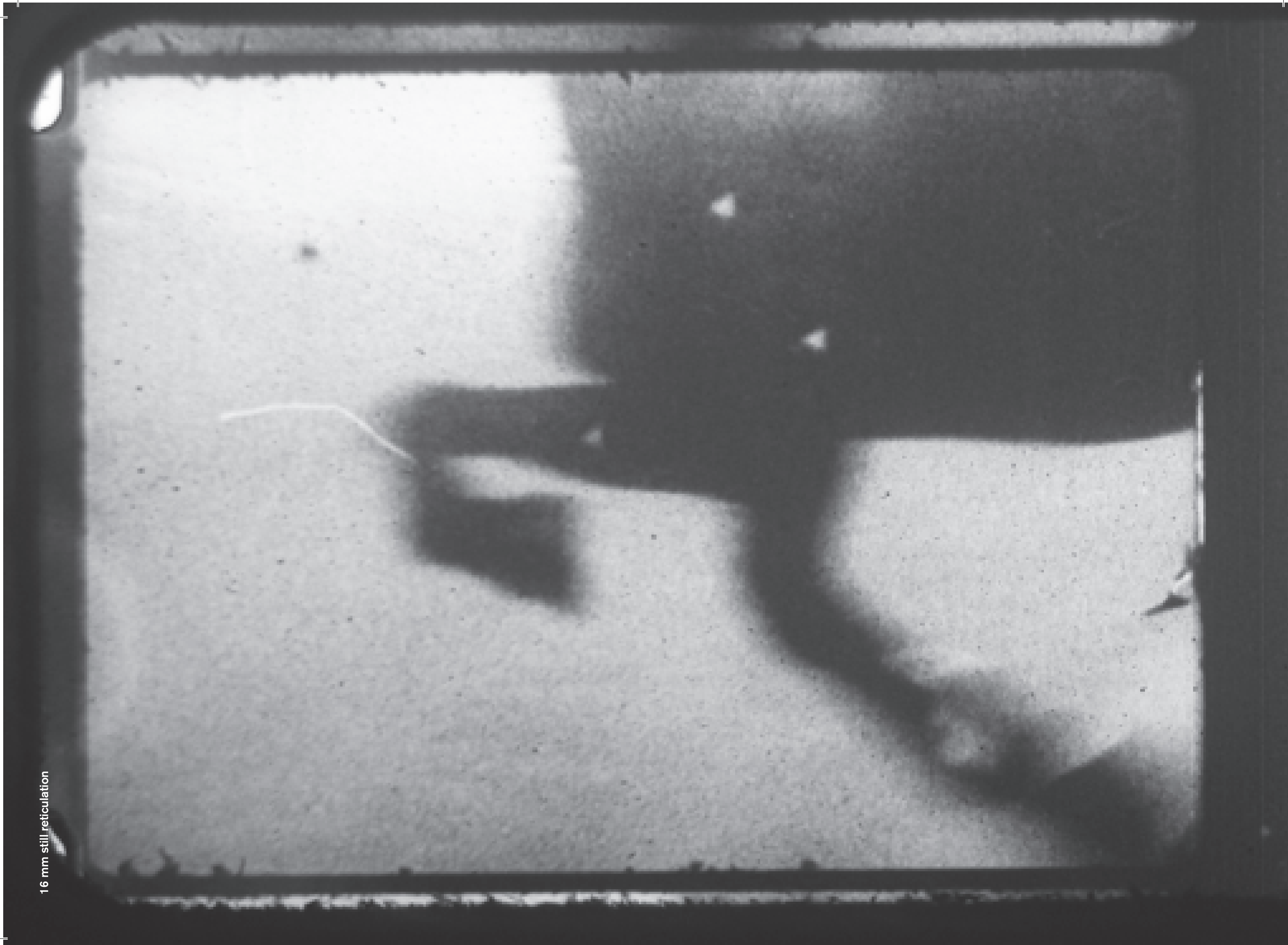
9 *Encyclopedia for Photo- and Cinematography* (Elsevier 1953-1958)

10 *Photo Technique* / P. Carpentier (1967)

11 *Coloured Black and White* / B. Hanlo (1996)

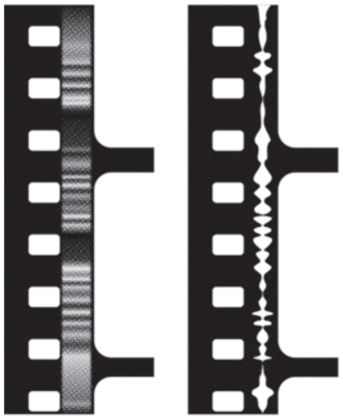
12 *Photography with Emulsions* / William de Wiveleslie Abney (1885)

13 *The Fundamentals of Photography* / C. E. K. Mees (1921)



16 mm still reticulation

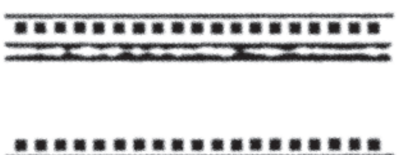
13. EXTRA'S: OPTICAL SOUND



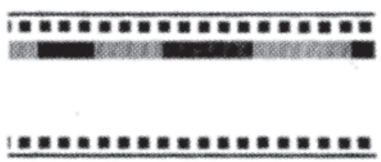
Sound on film

How it works

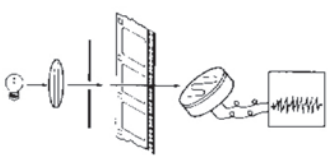
16 mm film works with an optical sound track situated in the frame line of the film. It works with a lamp shining through the optical sound track hitting a photosensitive cell. Because the sound-track varies in density, a light with varying intensity arises on the cell. A current controlled by the cell will proportionally vary with the illumination of the sound pattern, this alternating signal is amplified and thus made audible.



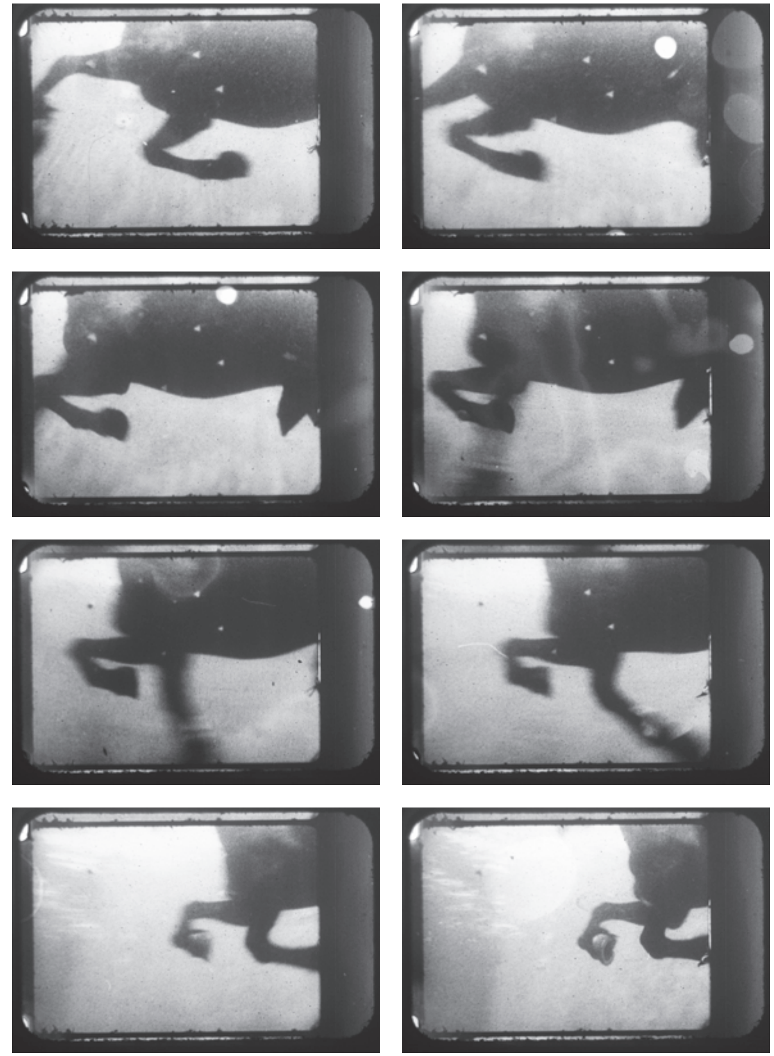
Left – variable area, width of transparent part varies with audio



Right – variable density, whole track varies in density with audio



Schematic of optical sound reproduction



16 mm stills basic emulsion: coating by brush
Esther Urlus, 2013