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(ILLUSTRATED).

By T. Thorne Baker. F.C.S., F.R.P.S.

(SECOND EDITION.)

CONTENTS.

No. 1

PRINT FROM A CORRECTLY EXPOSED NEGATIVE. *By T. Thorne Baker.*

—— Successful ——

NEGATIVE MAKING.

CHAPTER I.—All about the Dry Plate.

The dry plate—The action of light on silver salts—The essential differences between slow and rapid plates — The choice of plates—Orthochromatic plates.

THE state of photography nowadays is such that the amateur and professional alike are surrounded by an overwhelming mass of all kinds of materials—cameras, plates, films, papers, chemicals—with the inevitable result that any one individual who does not succeed with a certain class of goods will prefer to leave it and try another, rather than try to ascertain the reasons for his failure. It is not enough, furthermore, to be satisfied if we are successful; let us endeavour to find out why success has attended our efforts, every bit as much as failure, so that a clear knowledge of the principles of photography shall guide our future work, and make us as independent as possible of facts, formulæ, and friends.

It will be our aim in writing this book to put before our readers the ways and means of making a successful negative under ordinary, and difficult, circumstances, and we shall endeavour to give a simply-worded reason for everything that is recommended to be done, so that an intelligent interest may be taken in the work, which thereby becomes doubly fascinating.

The development of an exposed photographic plate is such an exceedingly familiar thing that we watch it without wonder, and simply regard it as a means to an end; but it is, in reality, a most wonderful scientific process, and is based upon the extraordinary properties of light and susceptibility to light of certain chemicals.

Before being in a condition to thoroughly understand and master development, a knowledge of the dry plate itself is essential, and we shall proceed without further ado to discuss the dry plates of the present day.

If we take a plate and examine it in the daylight, we shall find that it is a piece of glass with a coating of some cream-coloured or even slightly yellowish substance. This substance consists of a mixture of gelatin and "sensitive salts" of silver, the mixture in the wet state being known as emulsion.

But what is meant by sensitive salts of silver? Silver is a white metal as we ordinarily see it, but if it be dissolved in hydrochloric acid, it will become transformed into a white substance called silver chloride; this white compound, although not in the least like a metal, nevertheless contains every bit of silver that was dissolved in the acid; to prove this, a little of the white chloride of silver might be laid on a block of carbon, and the flame of a spirit lamp directed upon it by means of a blow-pipe, when the white substance would first become red hot, then part with its chlorine, and very soon nothing would be left upon the piece of carbon but a piece of metallic silver in the form of a tiny "bead."

Heat, then, is capable of effecting *reduction* in metallic salts, and we shall presently see that light is able to effect, to some extent, a similar result. For the salts of silver obtained by dissolving silver metal in hydrochloric, hydrobromic and hydriodic acid are all changed by light, and upon this peculiar property all photography depends.

The emulsion with which a dry plate is coated is made in the following way:—Two solutions are prepared, one of silver nitrate in water, and another of ammonium bromide and potassium iodide in water which has been made viscous by having gelatin dissolved in it; in order to keep the latter liquid, it is kept hot, otherwise it would set to a stiff jelly. In the dark-room the solution of silver nitrate is slowly poured into the hot solution of bromide and iodide, with the result that an infinite number of grains, or *granules*, of silver bromide and silver iodide are formed, which become surrounded with gelatin, and thus an opaque yellowish-white emulsion results. Here, however, we must digress for a moment. There are many makes of plates, and each one varies in speed, and as we know, slow plates are generally cleaner than fast ones, i.e., freer from fog, and there are a multitude of differences in the characters of quick and slow varieties, all of which we shall soon see explained away, when we come to consider how a slow plate is made, and how a fast one is prepared.

In the first place, a certain amount of ammonia is used in preparing an emulsion; sometimes it is mixed with the silver nitrate (ammonio-nitrate method), sometimes it is put along with the gelatinous solution of bromide and iodide, and at other times, again, it is added after the two solutions have been emulsified. But wherever it goes in, we have the following points to remember:—The more ammonia used, the quicker the plates, the larger the grain, the greater the tendency for fog in the plates ultimately.

Then again, cooking or digesting the emulsion by means of heat also increases the speed, but it also makes the grain larger, and as before, produces a greater tendency for fog.

Here, then, are the essential differences between slow and rapid plates, and in order to expose and develop plates properly, we must bear them in mind. The slow plate is coated with a fine-grained emulsion which has not been much digested; it keeps very clean during development; moreover, the grains of silver bromide, etc., being very small, the developer has a large surface of material to act upon, and great density is thereby obtainable. The rapid plate is coated with a coarser-grained emulsion, which *has* been digested, and one result of the digestion is that some of the silver bromide becomes actually dissolved in the gelatin, which thus itself becomes sensitised; the grains being larger, there are fewer of them, and the developer consequently has a smaller surface to act upon, and great density is more difficult to obtain; the tendency to fog in development is more or less marked.

These differences have been explained at some length because nowadays everyone is using—foolishly enough—the fastest plates they can get hold of, and several firms have recently put upon the market an extremely rapid brand which it will now be readily understood requires careful handling if success is to be ensured.

The emulsion is set to a jelly after its digestion, and is then cut up into thin shreds and soaked in water. The reason for this is that a soluble by-product is formed in the emulsion thus:—

Ag	NO_3	$+$	$Am\,Br$	$=$	$Ag\,Br$	$+$	$Am\,NO_3$
silver	nitrate	plus	ammonium bromide	gives	silver bromide	plus	ammonium nitrate

The ammonium nitrate is very deliquescent, and the plates would be always sticky if it were allowed to remain; after washing, the shreds are remelted, and the emulsion is then coated upon the glass. The plates, after being coated, are dried, cut to sizes, packed and sent out.

Let us now see what happens when a plate is exposed in the camera. Remembering that the plate is sensitive to light, care should be taken in every available instance to screen it from the light of the dark-room as well as from the daylight which peeps in through many a crack in the average dark-room. Until the plate is immersed in the developer, i.e. in the dry state, it is sensitive to the least ray of light, and on prolonged exposure even orange and red light will fog it. It is therefore always advisable when using very quick plates, to stand *between* the lamp and the slides or sheaths and plates, so as to screen the direct rays from them.

The plate once exposed, is an altered object. An impression has been made upon it which is invisible to the eye, but which has brought about such a chemico-physical alteration that the developer is capable of making it *clear* to the eye. This invisible picture produced by exposure is termed the "latent image;" the latent image consists of granules of silver bromide and iodide, which are so altered that a "developer" has the power of reducing them to metallic silver, *reduced silver* being black in appearance. Evidently, then, a developer has an effect upon silver salts which is comparable with that which light has; the only difference is that heat is capable of reducing compounds whether they have seen the light or not.

Suppose now that the picture photographed was a richly-coloured landscape—blue sky, green trees, red flowers, etc. How is the effect of colour as distinguished by the eye made evident on the plate? The ordinary form of dry plate is colour-blind, except in so far as violet and blue are concerned; if daylight were yellow, orange or red, we should get no result whatever on exposing a plate in the camera.

Let us take a few everyday examples. The landscape that we snapshot on a sunny day gives in the print a dead, white sky, whereas blue sky should be represented as grey in the print just as much as green leaves. A bunch of marigolds if photographed will appear almost black in the print, whilst it should really appear as a light grey. These discrepancies arise because the dry plate is only sensitive to rays of violet and blue light, and is insensitive to green, orange and red. But the so-called isochromatic or orthochromatic plates on the market are coated with an emulsion which has been rendered sensitive to green and orange by means of the addition to it of certain anilin dyes. The same effect can be produced at home by soaking an ordinary plate in a weak solution of, for example, rose Bengal, of the strength of one grain to a pint of water; such a plate, when dry, would be sensitive to green and yellow objects as well as blue and violet, and would be "orthochromatic." It is hardly necessary to say that the best kind of orthochromatic plate is red-sensitive also, but owing to the necessity for manipulating such a plate almost in darkness—it is obviously impossible to employ red light—the most popular are the green-yellow sensitive plates now made by practically all manufacturers.

The chemical power of the invisible "ultra-violet" and the violet rays of light is so great that whether a plate is orthochromatic or not, the former must be prevented from reaching the film, and the violet and blue rays must be weakened in intensity, so as to give the other less actinic colours an equal chance. This is accomplished by using a yellow glass or *screen* in front of the lens, but an increased exposure is consequently required.

Before concluding this chapter, we must once more point out the great importance of paying attention to the *reasons* for everything we do. Photography is so essentially a chemical science, that unless some knowledge of the properties of plates, chemicals, etc., be possessed, one must merely work in the dark. The careful reading of this chapter will not be by any means time wasted, but to briefly recapitulate the practical points contained in it, we may sum up as follows:—

(i) Whenever it is possible to use a plate of medium rapidity rather than a very fast one, do so. Coarse grain—fatal to enlarging and lantern-slide work—is thereby avoided, together with fogginess, lack of density and lack of latitude. The slower the plate, the bigger error can we safely make in exposure, the pluckier the result, and the cleaner. But, of course, for portraiture, and purposes where a fairly soft, well gradated negative is desired, a plate of the highest speed may be used.

(ii) All kinds of plates, and especially the newer very rapid plates, should be protected as much as possible from the dark-room light, as its direct rays will produce fog if given sufficient opportunity.

(iii) Ordinary plates fail to reproduce faithfully in monochrome any subject which is brightly coloured, and where special attention must be paid to correct rendering, an orthochromatic plate should be employed; a yellow screen is absolutely necessary under nearly all circumstances, in order to depress the abnormal sensitiveness of the plate to blue and violet light.

CHAPTER II.—Plates:—Speeds and Exposure.

The speed of plates—Its effect on their character—The use of lens diaphragms—Halation and its prevention—The preparation and use of orthochromatic screens.

A successful negative is most easily made in a direct way, and in order that normal development may produce a perfect negative, the exposure must be correct. An incorrectly-exposed plate can often be saved by modified development or after-treatment, as we shall show later, but to avoid all this, a thorough understanding must be made of the exposure.

Plates may be divided roughly into four classes:—(i) very slow, for copying and photo-mechanical work; (ii) slow plates, to which perhaps the term "Ordinary" is most generally applied; (iii) medium rapidity plates, including the so-called extra-rapid and snapshot varieties; and (iv) extremely fast plates—a class which has arisen during the last year or two.

Now a slow plate may be given twice the proper exposure, or even three times, and yet turn out well, whilst a rapid plate which has been three times over-exposed will be so flat that it is useless as a negative. In order, therefore, to be able to give any plate the correct exposure, it is necessary to know its speed, and the value of the light at the time of exposure. Speed is measured in many different ways, but in this country the Wynne and Watkins systems are most generally employed. A plate, for example, is labelled 180 Watkins; by this we know it is an extra rapid plate (class iii), and by means of a Watkins exposure meter we can calculate the necessary exposure within a fairly accurate limit. Similarly with Wynne.

It is not possible to describe here the means by which these speed numbers are obtained, but plates labelled with speed numbers as under may be described as being of the four classes above-mentioned respectively:—

Class.	Wynne Nos.	Watkins Nos.
i.—Process, or photo-mechanical ...	30—56	about 40—60
ii.—Slow	45—78	about 60—90
iii.—Extra-rapid ...	78—90	about 90—180
iv.—Extremely fast ...	90—135	about 180—800

N.B.—These figures are not equivalents.

Both the Watkins and the Wynne exposure meters depend on the time taken for a piece of specially-sensitised paper to turn from its original cream colour to a slate-blue standard tint, a sample of which forms a portion of the meter. From this time is calculated the necessary exposure, by employing the lens diaphragm number as a multiplying factor and the plate speed as the dividing factor.

The diaphragm of the lens is an important factor with regard to the character of the negative. The number F/11 for example, means that the diameter of the "stop" or "diaphragm" is then 1/11th of the focal length of the lens; the focal length being constant, it is clear that the stop F/11 is larger than F/22, and so on. Hence, if 1 second be the exact exposure for any plate with F/5.6, we shall require with

F/8	...	2 seconds
F/11	...	4 ,,
F/16	...	8 ,,
F/22	...	16 ,,
F/32	...	32 ,,
F/44	...	64 ,,
F/64	...	128 ,,

Most lenses have stops ranging from F/8 to F/44 or F/64, whilst some work up to F/4.5 and even more. But what must be borne in mind is that the smaller the stop, the finer will be the detail, the more vigorous the negative, and the greater the latitude in exposure.

It is evident that a smaller mistake is likely to be given in a long exposure than in a very short one, where it would be easy to give twice or three times the correct time. But it also seems a fact that if we use a fast plate and stop down the lens well, the conditions as regards density and latitude become very much the same as if a slow plate had been used with a correspondingly large stop.

Let us see how the character of plates varies with their speed. The class of negative required must be borne in mind throughout every operation—in the choice of the plate, the lens diaphragm, the exposure and the development. To begin with the very slow plate, it will be found that for every equal increase of exposure we get more than the corresponding amount of density; hence, the high-lights are denser proportionally than the half-tones and shadows; the result is a *harsh* negative. This is, however, precisely what is wanted for copying work, and in order to still further increase the contrast, a hard-working developer like hydroquinone is used. (See Chapter III.)

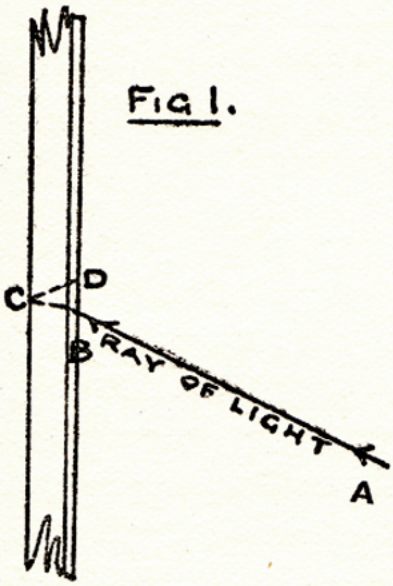
Slow plates should therefore be used in all cases where a bright, contrasty, clean negative with very fine grain is wanted, and in the summer months, if only more slow plates were used, there would be far fewer failures.

The most popular and useful plate for all-round work is the extra-rapid variety. With rapid plates one gets far better gradation, i.e., far more equal increments of density for equal amounts of exposure. Control over the character of the negative may be made in many ways. For example, a portrait is to be taken, and a soft, well-exposed negative is required, in which the shadows are filled with detail and not clogged up; the thing to do here would be to use a large stop, say, F/8, and to give ample exposure—one and a half times that calculated by meter—and to develop with a weak but not too restrained developer. Again, a brightly lit landscape is to be taken, in which there are certain shaded portions which it is feared will lack detail through under-exposure; a backed plate of medium speed would be required, and the exposure calculated for the least-lighted portions would be given, a weak developer being used with a *retarder* rather than a restrainer (Chap. III.). Another example is the architectural subject, such as a church, which on a fine day appears very bright—so bright that the detail in the stone-work seems almost hopeless to reproduce; in such cases as these stop down the lens to quite F.32, and give the proportional increase in exposure, not more, and develop with a vigorous developer, such as pyro-ammonia or hydroquinone. These are, of course, but a few instances of the wholesale control that is possible. The advantage of a Watkins or Wynne exposure meter cannot be over-estimated, only it must be remembered that when stopping down a lot it is always wise to give just a little more than the calculated exposure.

No matter what printing process we are to employ eventually, it is a *sine-qua-non* in a good negative that the densest portions shall be "printable" through, and the weakest portions shall not be transparent—except, of course, in the process negative. Halation is responsible for a lot of blocking-up in the high-lights, and the importance of preventing it must be remembered.

If you examine almost any negative which has been taken on an unbacked plate, of some bright subject, you will find that around the dense parts of the image there is a "halo," or in other words, the edge, instead of ending almost abruptly, is blurred, and encroaches on the rest of the picture. This blurring is caused in the following way:—The rays of light which pass through the lens meet the plate at all angles, and the film not being opaque, they pass through it, and, of course, reach the front surface, and finally the back surface, of the glass; reflection takes place, and the rays of light return at an angle depending on their original path, with the result that when they again reach the film they act upon it and cause a secondary image; several of these secondary images are produced, and they overlap one another, thus producing an indistinct blurr. Look for a moment at Fig. 1. A ray of light AB comes from the lens, meets the film at B, and passes through the glass, being then reflected at C. The reflected ray CD meets the film again at D, and so any image caused at B is repeated to a lesser extent at the point D.

Now this is very easily prevented, and as there is practically no cure for halation, prevention is an important subject. For interior work it is essential to prevent it, as otherwise halation will take place around all the brightly-illuminated parts, such as windows, etc., long before the dark parts are sufficiently exposed. For landscape work it almost invariably pays to prevent it, and it is absolutely necessary in the case of woodland subjects, especially where a prolonged exposure with an orthochromatic plate and screen is being given. It is not of much value as a rule in portrait work, as care should be taken that a soft lighting is given with no vigorous contrasts. For copying work, photo-mechanical and three-colour work, the backed plate is again a thing of necessity.



The prevention, then, of halation is effected by applying a "backing" of some absorbent medium to the glass side of the plate. In roll film photography this is practically done for us, as the film is rolled up along with dull black paper. But to make an effective plate backing it is very necessary for the medium to be in optical contact with the glass; and, scientifically, it should be of the same refractive index as the glass, as otherwise the maximum of light will not be absorbed, but some will still be reflected.

When using orthochromatic plates, which are sensitive to green and orange rays, a coloured backing medium cannot be used, and we mention this fact because so many of the media advocated are prepared with burnt sienna. A dead black backing in any case is the best to use, and it should be prepared in some form which can be both easily applied and readily removed before development.

A very good backing medium which can be brushed on to the glass side of the plate may be made by mixing together the following:—

Ordinary gum ...	1 ounce or 30 ccm.
Caramel	1 ounce or 30 gms.
Finely ground Indian Ink	1½ ounces or 45 gms.
Methylated spirit ...	2 ounces or 60 ccm.

This should be allowed to dry before the plates are put into the dark slides, and then before development it may be removed with a damp sponge.

The nicest method of working is undoubtedly to prepare backing sheets. Several pieces of strong note-paper are cut to the size of the plates used. They are coated with the following mixture:—

Gelatin	1 oz.
Water	8 oz.

This is dissolved with the aid of heat, and then is added:

Nigrosin (sol. in water) ...	½ to 1 oz.
Water	2 oz.

This is thoroughly mixed up with the water in a mortar, and then stirred in with the gelatin solution. The mixture is filtered through muslin, poured into a dish, and the pieces of paper coated by three minutes' flotation at about 95° Fahr. Each sheet when coated is pinned up to dry.

The plates to be backed are laid film downwards on a piece of clean paper, and the glass side thoroughly cleaned with a rag and a little French chalk. A sheet of backing paper is then wetted, and squeegeed into contact with the glass. After exposure, it may be stripped off the glass, and used again.

Having now considered the exposure and treatment of ordinary plates previous to their development, we must look into the subject of exposing orthochromatic plates, as photographers are at length awaking to their great advantages. It is only under exceptional circumstances that any advantage is derived from an orthochromatic plate when used without a screen, or light filter, for the following very simple reason.

Both orthochromatic and ordinary plates are so susceptible to blue, violet, and the invisible but ever-present ultra-violet rays of light, that unless some means is taken of checking their action, they will produce an image on the plate long before the other colours have had a chance to produce any impression whatever. Hence, the added colour-sensitiveness of the orthochromatic plate cannot give any advantage.

Consider for a moment what a lot of reflected light there is with almost every open landscape subject. If from this reflected white light we cut off the two-highly actinic colours, we then give the

A DERBY-SHIRE DALE

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By T. Thorne Baker

A. *B.* *C.*

CLASS OF PICTURE OBTAINED WITH DIFFERENT PLATES.

Fig. 3.

"A" is harsh: Process Plate

"B" is correct for the subject: Extra-rapid Plate

"C" is soft: Extremely-rapid Plate

colour-sensitive plate a chance to assert its wonderful powers. But the colour filter has another most important function to perform. It has to compensate for the deficiencies in colour sensitiveness of the particular brand of plate you are using. Thus, if we bathe a plate with thiazol yellow, it is rendered green sensitive; if we bathe it with erythosin it is made yellowish-green sensitive; if we bathe it with glycin red it will become orange sensitive. The plate bathed with thiazol yellow, with erythosin or with glycin red would be called "orthochromatic;" they are therefore all "orthochromatic," which is ridiculous, because an *ortho*chromatic plate is one which is sensitive to all colours in the same relation as the eye. To the eye yellow is the brightest colour, and must therefore produce the most effect on the plate, and the other colours must produce effects proportionate with their eye luminosities.

We must remember, then, that the screen has primarily to be yellow in order to check the blue-violet components of the picture, and it must transmit any other colours in *inverse* proportion to the sensitiveness of the plate to those colours.

Very fairly accurate renderings can be obtained by employing a simple yellow screen with most makes of orthochromatic plates, and it is very interesting work to make a few such colour filters on an experimental scale. The recognised method is to fix a few lantern plates in plain hypo and water, thoroughly wash them, then dry them; the gelatin-coated glasses thus obtained may be stained with certain of the anilin dyes, again dried, and after being cut to the most convenient size, bound up with a cover glass, just like an ordinary lantern slide. We shall explain an extremely simple way of fixing them to the lens later on.

A suitable staining bath for an orthochromatic screen may be prepared as follows:—

Naphthol yellow	10 gr.
Water	1 oz.

The naphthol yellow takes a few hours to quite dissolve, and in order to make sure that every particle *is* dissolved in the solution used, it should be filtered. The exact strength of the dye does not, of course, matter, but the slower the staining, i.e., the weaker the solution, the better. To avoid streaks or patches, keep the dish rocking gently during the staining, and every few minutes remove and look through the plate; when it appears of a light lemon yellow colour, it may be rinsed under the tap and allowed to dry in a warm place.

The best plan is to make three or four screens of varying depth of colour, and then to try experimentally which gives the best results. Remember that there are the two kinds of colour-sensitive plates—the ordinary orthochromatic, yellow-green sensitive plate, and the infinitely superior panchromatic plate, which is sensitive to every colour including red. For these latter plates it is best to use a slightly orange screen, and one may easily be made by soaking a fixed out (or gelatin-coated) plate in:

Aurantia	10 gr.
Water	1 oz.

This should be made dark enough to necessitate an increase in exposure of about 10 to 15 times.

The dried " screens " may be cut up with a diamond to squares, the side being a just a little longer than the diameter of the lens hood. A cover glass of the same size is well cleaned and bound up with it like a lantern slide, to preserve the film from scratches.

We now come to the *exposure* of the plates. It is very important to first of all consider the nature of the light. For instance, if you are photographing in a wood where the colours are brilliant and the light soft, you will not require anything like such a dark screen as you would in an open landscape where there is a lot of bright reflected light to deal with. Too deeply coloured a screen always gives *over-correction*, and an over-corrected photograph in which the greens and yellows appear very light is a ghastly failure. Do not think that because your screened photograph shows a violent contrast to that taken on the ordinary plate that it is a thing to be proud of! What is wanted is a picture in which the components are rendered according to their brightness to the eye. Look at the frontispiece to this book, for example; this was taken in a woodland glen where the colours were so rich that we dare not even use a screen at all; yet the orthochromatic plate has done its work perfectly satisfactorily,—with a screen the picture would have been over-corrected.

When photographing flowers always arrange that the lighting is soft, and if possible that some light comes from behind, and therefore brightens the petals, etc., by transmission.

When photographing pictures, a plate which is red sensitive is absolutely essential, and an orange-coloured screen such as that made with aurantia will give an excellent rendering with about 20 times normal exposure. Do not forget to focus *through the screen,* as the focal length of the lens is slightly altered.

Finally, we would describe the very simple screen-holder which we always use, as it costs nothing, and is extremely convenient. A piece of sheet brass about 1/32nd of an inch thick, and 1 inch square in area is prepared, and bent in a U shape, as shown in Fig. 2 by B, so that the screen S fits just comfortably into it; remove the lenses from the brass tube, and solder the "screen-holder" B to the hood H. A behind-lens shutter is, of course, then necessary; and the only alternative to the behind-lens shutter is to use a circular screen which fits with a spring-ring inside the lens tube or hood.

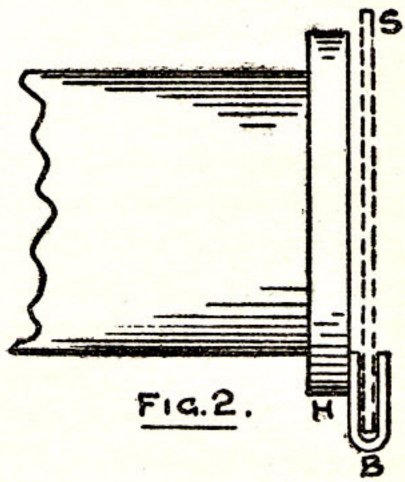


FIG. 2.

CHAPTER III.—Development.

The chemical effect of light—Development of the exposed plate—The components of a developer, and its construction —The characteristics of the well-known developing agents—Special treatment of various kinds of plates—Stand development.

During the exposure of a plate or film in the camera, the image formed by the lens may only have acted on it for a thousandth part of a second, but once exposed, a chemical change has been undergone by the sensitive silver compounds. Whether this change is actually chemical or physical in character cannot be positively decided, but if the former, then the change produced by the action of light is of such a nature that it admits of chemical development. A clean-working plate might be developed, without any exposure, for an hour, and no darkening would be observed, but once exposed, the developer would immediately have the power of darkening it, so that in a very few minutes the whole lot of silver bromide and iodide would be converted into metallic silver, or low compounds of silver. That the black image of a negative does not consist of absolutely metallic silver has been shown conclusively by Dr. Lüppo-Cramer.

The process of converting a metallic salt like silver bromide, $AgBr$, into the metal, Ag, is termed reduction, and the developer is therefore primarily a *reducer*. Thus pyrogallol, metol, amidol, etc., are reducers, or reducing agents.

A developer, then, consists essentially of three parts :—

(A) The reducer, which is kept from oxidation by the presence of a preservative.

(B) An alkali, which accelerates the reduction owing to its power of destroying the *acid* liberated in development; for an acid restrains development.

(C) The restrainer or retarder, such as potassium bromide or citrate.

Now if we once understand the principles on which a developer is constructed, we shall be independent of formulæ and can make up our own with any suitable reducing agent. It must be borne in mind that the developers pyro, hydroquinone, edinol, glycin and eikonogen, require from five to ten times their weight of some alkaline carbonate, and three to six times their weight of sulphite, and one hundred to three hundred times their bulk of water to prepare with them a developer. Thus, suppose we take one ounce of eikonogen, five ounces of sodium carbonate, three ounces of sodium sulphite, and two hundred ounces of water, we shall have made a developer.

The factors which determine the quality of a developer are as follows:—

(1) The proportion of carbonate or alkali to reducer; the more reducer, the greater the density of the negative.

(2) The proportion of preservative to reducer; the more preservative, the slower the action of development.

(3) The proportion of restrainer to reducer; the more restrainer, the greater the contrast given, the slower the development, and the less the effective exposure; i.e., bromide

destroys to some extent the effect of the exposure.

It is very important before we develop a plate to make up our mind as to what class of negative we require. If a harsh negative be wanted, with great contrast and very dense high-lights, it will be advisable to use, first of all, a plate with a steep gradation curve, then to slightly under-expose it, and finally to use a developer which will accentuate these features. But if we want a soft, well-gradated negative in which the deepest shadows contain detail, and the contrasts are soft and artistic, we shall want to use a plate of medium speed, to give full exposure, and finally to develop with a soft-working developer. On these few points the whole success of the negative depends.

If you look at Fig. 3, you will see three photographs taken of the same subject; one on a process plate, one on an extra-rapid plate, and the third on an extremely rapid plate. You will see that A is very harsh in character, B brilliant and plucky, and C soft and nicely gradated. Now we want to show in the next few pages precisely how these varying results can be produced on the *same* plate by modification of the developer.

Every developing agent has fairly-marked characteristics. Hydroquinone, when used by itself requires a caustic alkali to bring about the development properly, and it then gives very harsh results with great depth in the blacks, and little depth in the least exposed parts. This is exactly what is required for process work, picture and diagram copying, copying old photographs, etc., and the following solution is the most satisfactory:—

*A.—Hydroquinone ...	40 gr.	or	4 gm.
Pot. metabisulphite	40 gr.	,,	4 gm.
Pot. bromide ...	16 gr.	,,	1·6 gm.
Water	10 oz.	,,	500 ccm.
B—Caustic potash ...	80 gr.	or	8 gm.
Water	10 oz.	,,	500 ccm.

Equal parts of these solutions are used.

We next come to the most universally used class of plate, which is, as often as not, called "extra-rapid." These plates, of about 200 to 250 H. and D. (with pyro-soda), have the great advantage of working cleanly, whilst by modifying the developer, almost any class of negative is obtainable.

Assuming that the reducing solution is termed A, and the accelerator B, it will be evident from what has already been said that more A, less B, will give density; more B, less A, will give softness. Bromide added before development has commenced will partially destroy the latent image, and therefore reduce the effect of exposure; added after the image has once appeared, it merely slows the action and does little good.

That a developer containing a lot of bromide will increase contrast is obvious from the following:—In any exposed plate the latent image necessarily consists of very slightly altered AgBr, more altered AgBr and greatly altered AgBr, according to the effect of the light coming from different parts of the original. If bromide has the power of destroying this action to some extent, it will restore to the normal (unexposed) condition the slightly altered AgBr, partially restore the more altered AgBr, and, *comparatively*, have little effect upon the most exposed AgBr.

*The metric and English weights are not necessarily equivalents, in this or any other formulæ.—See also note on page 42.—T.T.B.

On development, consequently, the more exposed parts will be reduced more freely than the less exposed, whilst the shadows or faint parts may not develop up at all, having been "bromised" into normal silver bromide again.

We have no hesitation in saying that for all-round work there is no developer like pyro-soda. Any amount of density, any extent of softness, can be produced readily with it, and it is a developer which stands the hot weather well, i.e., does not give abnormal fog or veiling of the whites. A thoroughly reliable formula is as follows:—

A.—Pyrogallol ...	90 gr. or	6 gm.
Pot. metabisulphite	45 gr. ,,	3 gm.
Water to	10 oz. ,,	300 ccm.
B.—Sodium carbonate	$1\frac{1}{4}$ oz. or	37·5 gm.
Sodium sulphite	$1\frac{1}{4}$ oz. ,,	37·5 gm.
Water to	10 oz. ,,	300 ccm.
C.—Potassium bromide	1 oz. or	30 gm.
Water to	10 oz. ,,	300 ccm.

It is far more satisfactory to have the bromide in a separate bottle, and to add it as required.

When developing the exposed plate, the printing process to be ultimately used should always be borne in mind. Thus for P.O.P. printing, one requires a fairly soft negative without too much contrast and density. Bromide printing requires a fairly plucky negative, with good blacks. Gaslight paper, a soft, well-exposed negative. Carbon paper works best with a fairly soft, well gradated negative, and platinotype, on the other hand, requires a negative with good contrast and pure whites. For lantern slide making one wants really harsh negatives to get the best results, and it will be found that a hydroquinone developer gives almost the most suitable negatives.

Whether landscape, portrait or architectural subject, the plate may safely be developed with a mixture of equal parts of A and B, two drops of C being added to each ounce or 30 ccm. of the mixed solution. Of course, in cases of known over-exposure, more A solution and bromide should be added. But under ordinary circumstances, one only hopes that the plate may prove correctly exposed. Should the image flash up very quickly, pour the developer into a measure, fill the dish up with water, and then add more A and a little bromide to the mixed developer; then pour the water away, and pour the developer again into the dish. If the plate is clearly much over-exposed, only carry development just far enough to bring out the details in the shadows; then remove and fix it, and reserve it for subsequent intensification.

When the image is some time in coming up, and the plate seems under-exposed, the development should be allowed to proceed slowly rather than be accelerated by too much alkali.

It is never advisable, for example, to work with more than two parts of B to one of A, as the extra accelerator always tends to give fog, and this fog is increased if the plate be intensified. If on prolonged development with extra B solution the image still appears underdone and chalky, fill the dish up with water, and having thus diluted the developer, allow the plate to "soak" in it for fifteen or twenty minutes before fixing, or even longer.

It will be clear now that, as over-exposure gives flatness, and under-exposure gives too much contrast, if a soft negative is required, the plate should be well exposed, and developed as if it were *under-exposed*. Similarly, if a plucky, clean negative is required, it should be well exposed, i.e., sufficiently to record the details in the shadows, and developed as if *over-exposed*.

A good all-round developer for snapshot and landscape work may be made up with metol and hydroquinone, as follows:—

Water (total bulk) ...	40 oz.	or 1,200 ccm.
Pot. metabisulphite	20 gr.	„ 1·25 gm.
Metol	20 gr.	„ 1·25 gm.
Hydroquinone ...	64 gr.	„ 4 gm.
Sodium sulphite ...	1 oz.	„ 30 gm.
Sodium carbonate ...	$1\frac{3}{4}$ oz.	„ 52·5 gm.

Use two drops of ten per cent. bromide to each ounce of developer.

It should be noted that in warm weather a developer containing metol is liable to fog the plates unless kept below 65° Fahr.

We next come to the development of the comparatively new brands of extremely quick plates, which are all very well for indoor portraiture, focal plane work, and so on, but which give a good deal of trouble unless used carefully with outdoor and other exposures. Not for one moment would we condemn such plates, but their indiscriminate use is certainly inadvisable, as they require careful handling. In the first instance, they exhibit colour sensitiveness, and must therefore be shielded from the rays of the dark-room lamp as much as possible. Moreover, when they are used under conditions which require all their available speed, the use of bromide should, if possible, be avoided, and we therefore recommend a developer restrained with sodium citrate, such as the following:—

A.—Pyrogallol	 30	parts
Citric acid	 25	„
Sodium sulphite	 150	„
Water to	 1,000	„

B.—Sodium carbonate	 250	parts
Water to	 1,000	„

Development should be started with three parts of A to two of B; if the plate appears under-exposed, the remaining part of B can be added.

Orthochromatic plates also require careful handling in order to give the best results. It may be taken as a general rule that the yellow-green sensitive varieties are inclined to be harsh, i.e., the negatives will possess too steep gradation. It is always safe, therefore, to err slightly on the side of over-exposure, especially when exposing through a screen. Also, the developer can be made a little stronger in alkali, or again, a metol developer can be employed, or some reducer, such as edinol, which does not too readily give contrast. A solution containing five grains each of edinol and potassium metabisulphite, and sixty grains of sodium carbonate to the ounce of water will give very pleasing results.

It is, however, a mistake to think that any one developer is better than another for colour-sensitive plates.

For red sensitive plates the time method of development is sometimes valuable. The time taken for the first signs of the image to appear is multiplied by a factor depending on the developer, and the total time thus obtained is allowed. But as a matter of experience we recommend developing panchromatic plates in a pyro-soda developer for three to four minutes in complete darkness, during which time their red-sensitiveness is greatly diminished, and then using the least possible amount of light for watching the plate during the completion of development.

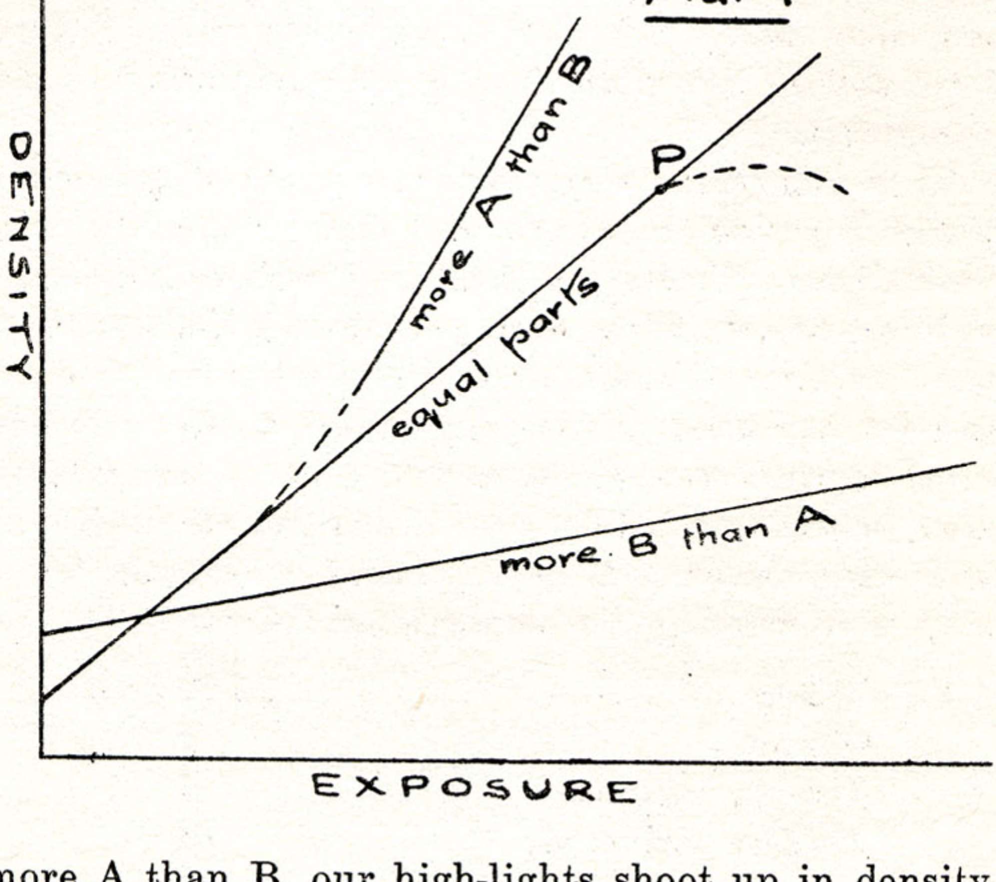
It is sometimes a convenience to develop several plates together in a grooved dish or trough in a very dilute solution, so that they will take perhaps an hour or two, and can be examined at leisure from time to time. When developing a series of hand-camera exposures of varying subjects, etc., one has more control over the operation; but *stand development*, as this method is termed, has not received very wide application. A good, reliable formula for a very slow-working developer is as follows:—

A.—Water	 2,500	parts
Glycin	 5	„
Sodium sulphite	 5	„
Sodium carbonate	 45	„

Glycin is generally used on account of its exceptional cleanliness, and the time required to attain great density with it.

In conclusion of this chapter, we should like to point out graphically the characters of the negatives obtained by using a greater proportion of A than B, and of B than A, etc. A properly exposed plate, developed normally, should give equal increases of density for equal increases of exposure, and the line marked "equal parts" shows graphically the character of such a negative. Using more B than A, we get less density in the high-lights and more in the shadows, as shown by the bottom "curve," as compared with the normally developed plate. With

FIG. 4



more A than B, our high-lights shoot up in density, and give more than their correct proportion. Lastly, at some such point as P reversal will begin, and this is shown graphically by the curve turning downwards, so that for any further increments of exposure after P we get *less* density instead of more.

CHAPTER IV.—Fixing and Washing.

Treatment of plates after development—Fixing—Acid fixing baths—Combined development and fixing—Hardening baths—Washing—Hypo elimination—Drying negatives spontaneously and rapidly.

During the development of a plate the film absorbs a certain quantity of developing solution, and if it be transferred immediately to a solution of hypo, some seconds elapse before the latter can displace the former, and therefore arrest its action. If, therefore, it is a matter of necessity to stop development at a certain point, it should either be at one placed in running water for a minute before it is transferred to the fixing bath, or else an acid fixing bath must be employed. The developer, in reducing the exposed bromide of silver, sets free acid, which it is the rôle of the accelerator (being alkaline) to *neutralise*; the presence of an acid retards development, and in excess will immediately stop it.

The reasons for " fixing " a plate are clear. When development is finished, we have a reduced silver image, surrounded by the original creamy-white bromide and iodide of silver; these salts are obviously still sensitive to light, and must therefore be removed from the film. Hence the plate is immersed in a solution of some chemical which possesses the power of dissolving silver haloids such as the bromide, iodide, etc. In former days potassium cyanide was used for this purpose, but nowadays, owing to its cheapness and efficiency, hypo is almost exclusively employed.

Hypo, or sodium thiosulphate, is a sulphate of sodium in which an atom of sulphate has replaced an oxygen atom; thus the chemical formula for sodium sulphate is $Na_2\ SO_4$, and that of hypo is $Na_2\ S_2\ O_3$; it can be made quite easily by dissolving some sodium *sulphite* in water, and keeping it at about 80° C. whilst flowers of sulphur are stirred in until no more will dissolve:—

$$Na_2SO_3 + S = Na_2S_2O_3.$$

When a plate is put after development into the fixing bath, the black silver image remains unaffected, whilst the unaltered salts become first converted into a double compound of the formula $Ag_2S_2O_3Na_2S_2O_3$; finally, owing to excess of hypo, we get $Ag_2S_2O_3$, $2\,Na_2S_2O_3$—a substance which readily dissolves. This teaches us that an excess of hypo must always be present; that insufficient fixing, or fixing in an old, used-up bath, though it may cause the whiteness to disappear from the film, has nevertheless not completely removed the silver salts, and therefore—on keeping—these *invisible* salts remaining in the film will gradually become decomposed into silver sulphide, thus causing yellow and brown stains.

It is possible to carry on development and fixing at one time in the same bath, and though we do not recommend this treatment for ordinary work, it certainly opens up a most interesting field for experiment. According to the formula we originally suggested ("The Photographic Journal," January, 1904), the following will be found to develop and fix simultaneously:—

Hydroquinone	1·5	parts
Pot. metabisulphite	3	,,
Caustic soda	8	,,
Pot. bromide	·1	part
Hypo	20	parts
Water	200	,,

It will be wise to experiment first with a few well-exposed lantern plates; better results can be obtained with *contact* exposures than with plates exposed in the camera. Potassium cyanide has also given some very satisfactory results, but a less quantity of it is required than when working with hypo.

The quantity of hypo used in the fixing bath varies according to the make of plate used, but in general a solution of:

Hypo	5 oz.
Water	20 oz.

will be found to answer well. Some makes of plates contain a larger percentage of silver iodide than others, and these require a very strong bath, such as eight ounces of hypo to the pint of water.

It will be found that with metol-hydroquinone and developers containing *carbonates* a sediment is frequently formed on the film. This may be removed by a weak acid bath (commonly called a clearing bath), or the acid itself may be incorporated with the fixing solution.

The further advantage of an acid fixing bath is that already alluded to, viz., that it at once arrests development.

The addition of a mineral acid to the fixing solution causes the precipitation of sulphur in it, and must therefore be rigorously avoided. The bisulphites contain a certain amount of active sulphurous acid, and are the most satisfactory to use. Of these, perhaps the best is acetone sulphide, and this compound may be mixed with the hypo in the proportion of about one to sixteen. Thus an excellent acid fixing bath is prepared as follows:—

Hypo	8 oz.
Acetone sulphite	½ oz.
Water	40 oz.

This will keep indefinitely, and will remain clean and clear until exhausted.

Another reliable formula is the following:—

Hypo	5 oz.
Sodium bisulphite	1 oz.
Water	20 oz.

If you do not want to make *all* your fixing solution acid, so that it can be used for either plates or P.O.P. at will, make up a stock solution of:

Hypo	16 oz.
Water to	80 oz.

This may be used for P.O.P. as it is, whilst for plates and bromide paper, to each 10 ounces must be added one ounce of the following

ACID SOLUTION.

Sodium sulphite	½ oz.
Citric acid	¼ oz.
Water	4 oz.

Never add acetic, sulphuric or hydrochloric acid to the fixing bath, as it will at once turn milky, owing to the precipitation of sulphur.

In hot weather it is sometimes necessary to employ a hardening bath, in order to prevent *frilling* at the edges of the film. Alum, chrome alum, or formalin are the recognised agents for hardening, and they are of power increasing in the order named. Thus, a five per cent. solution of alum may be used, a one per cent. solution of chrome alum, or a very weak solution of formalin. Blistering is most frequently caused by transferring a plate from a warmish developer to a freshly-made and therefore very cold fixing bath; it is essential to avoid sudden temperature changes when dealing with gelatin.

As regards washing plates and films, there is little to be said; one hour in running water should be sufficient, but giving eight or ten changes of water is generally quite as satisfactory. Where much depends on the washing, it is the wisest plan to make certain of the elimination of hypo by the use of some such compound as hydrogen peroxide, iodosal, Lumiére's Thioxydant or Bayer's Fixing Salt Destroyer.

The importance of ridding the film from hypo is as follows:—A negative whose film contains a trace of hypo will not be permanent, as sulphide of silver will eventually be formed; also, hypo plays chemical havoc with intensifying baths, and causes stains to result if they be used.

An effective hypo eliminator may be made by mixing 1 drachm or 25 ccm. of "20 vol." hydrogen peroxide with 5 ounces or 1,000 ccm. of water. This will remove all traces of hypo in two minutes; a short final rinse then completes the washing.

Drying negatives is an operation which deserves more attention than it usually receives. The avoidance of dust is of the greatest importance, and the maintenance of an even temperature. If on drying, purple or brown comet-like marks appear on the film, it may be taken for granted that the tap water contains an abnormal quantity of iron; this is obviated by tying a piece of swansdown over the tap to filter the water as it comes through.

The rapid drying of plates is effected by immersing them, after being well washed, in methylated spirit for ten minutes. They may then be removed, and after a few moments held about two feet away from a fire, or Bunsen burner, film side *away;* in this manner a plate will generally dry within ten minutes. It should be remembered, however, that it always appears to be dry some minutes before it is actually safe to print from it, as after it has assumed the appearance of being dry, the gelatin is still tacky. Often on drying with spirit one finds white leaf-like patches appearing in the film; this is a sure sign that the plate has been imperfectly washed, and another soaking in running water will readily remove the trouble.

CHAPTER V.—Intensification and Reduction.

The after treatment of the negative—Intensification—Reduction—Local treatment.

It frequently happens that a negative, when finished, is not all that could be desired, and that we must therefore resort to some after treatment which will counteract or remove its deficiencies. It also happens that a negative which has been made soft, for example, in order to suit a certain contrasty brand of gaslight paper, requires modification in order to make it fit for platinotype, or some other process which demands a more vigorous plate.

In copying work, where one aims at getting a negative full of vigour, but entirely free from fog, it is customary to "cut out" by means of a preliminary reducing bath; thus a half-tone picture requires the fog to be moved from around the dots, so that they appear clean and crisp. This preliminary reduction is also advisable in the case of a flat, over-exposed, but rather over-developed negative. We shall therefore revert to reducing baths a little later on.

Intensification, as its name implies, is a process used to add density to a negative which is too weak or thin. There are three classes of negatives which require intensification, namely, under-exposed, harsh negatives, normally-exposed but under-developed negatives, and over-exposed, flat negatives. On a little reflection it will be obvious that you cannot use the same process for all three classes—at least, not successfully. While intensifying the shadow detail with a harsh negative, you do not want to add to the dense high-lights; similarly, the reverse is the case with the over-exposed negative: you want to add more to the high-lights than to the shadows. A judicious choice of intensifier is consequently necessary.

One of the best all-round intensifiers is the mercury bath, which converts the black image into white silver-mercurous chloride; when "bleached," the plate has to be then re-blackened, and for this purpose various re-agents can be employed, each one differing in its effect on the original gradation of the negative. During re-blackening, the silver-mercurous compound formed in the bleaching is reduced to metal, and the image thus becomes enriched by its combination with another metal.

Take care to thoroughly wash the negative before intensifying; it is absolutely essential to eliminate the hypo from the film, or stains and patches will result. The bleaching bath is made as follows:—

Mercuric chloride ...	60 gr.	or	4 gms.
Ammonium chloride	30 gr.	„	2 gms.
Water	5 oz.	„	150 ccm.

Leave the plate in this until the film looks quite creamy-white. Then wash it for five minutes in running water or several changes, and finally re-blacken it in one of the following solutions:—

A.—For Under-exposed Negatives.

Ammonia (·880) ...	1 oz.	or	part
Water	9 oz.	„	parts

B.—For Normally-exposed Negatives.

Acetone sulphite ...	1 oz.	or	part
Water	10 oz.	„	parts

C.—For Over-exposed Negatives.

Hypo	... ...	2 oz. or parts
Water to	... ...	10 oz. „ „

The plate will re-blacken in a few moments; it is then washed and dried.

Alternative methods are the following:—For under-exposed negatives the one-solution uranium bath, prepared thus:—

Uranium nitrate ...	30 grs. or	2 gms.
Pot. ferricyanide ...	15 grs. „	1 gm.
Acetic acid ...	3 drops „	3 mm.
Water	5 ozs. „	150 ccm.

This bath imparts a reddish colour to the negative, and sometimes discolours the whites; in the latter case it should be left to soak for five minutes in a solution of:

Ammonium sulphocyanide ...	1 part
Water	20 parts

The chromium intensifier is extremely good, and requires two operations. The well-washed negative is allowed to turn quite yellow in a solution of:

Pot. chromate ...	30 grs. or	2 gms.
Hydrochloric acid (conc.)	10 drops „	1 ccm.
Water	5 ozs. „	150 ccm.

It is then well rinsed, and re-developed with a hydroquinone or metol-hydroquinone developer. When re-blackened, it is merely washed and dried.

Similar to chromium is the manganese bath, which is particularly adapted to thin and under-exposed negatives.

A solution is made up of:

Pot. permanganate	30 grs.	or	2 gms.
Hydrochloric acid	5 drops	,,	·5 ccm.
Water	4 ozs.	,,	120 ccm.

The negative is immersed in this until it appears bright-red in colour. It is then quickly washed in running water, and re-blackened with a metol-hydroquinone developer as before.

We come now to the process of reduction. The essentials of a good reducer are that it must not attack the weakest portions of the picture too vigorously, and that it work slowly, so that its action can easily be stopped at the desired stage of reduction.

Although numerous reducers have been suggested and put upon the market from time to time, we cannot help thinking that the pioneer—hypo and ferricyanide—still stands unequalled.

An ordinary fixing solution, containing about four or five ounces of hypo per pint, will suffice, and to four ounces of this from twenty to sixty minims of a ten per cent. solution of potassium ferricyanide are added. The plate is immersed in this, and taken out and examined, perhaps twice each minute, until the requisite amount of reduction has been effected. The negative is then removed, and well washed. Another reducer is that prepared with potassium permanganate; five grains of this compound are dissolved in a pint of water (1 gm. in 2 litres), and to each two ounces (or 60 ccm.) a couple of drops of strong sulphuric acid are added; the action is fairly slow and even throughout the negative. Should any brown stain be caused by precipitation of manganic oxide, a short immersion in

Water	... ...	4 oz. or	120 ccm.
Sodium sulphite	...	300 gr. ,,	20 gms.
Oxalic acid	...	60 gr. ,,	4 gms.

will remove it.

A one in forty solution of ammonium persulphate is a useful reducer in cases where the negative is harsh, as it attacks the high-lights most vigorously. As the action is liable to continue during the after-washing, the plate should be removed a little before it is sufficiently reduced. Should the negative become at all discoloured, a minute's soaking in the ordinary fixing bath will restore it to the normal state.

Little need be said as regards local treatment. Do not locally reduce or intensify a negative you prize until you have practised on a few old ones. A little glycerine mixed with the solution will assist in localising its action, and a wad of cotton-wool will be found better than a brush for its application.

It is a good plan to use a uranium intensifying solution, as if the result be unsatisfactory, the negative may be readily restored to its original condition by a short immersion in a twenty per cent. sodium sulphite solution.

T. THORNE BAKER, F.C.S., F.R.P.S.

MEMORANDA.

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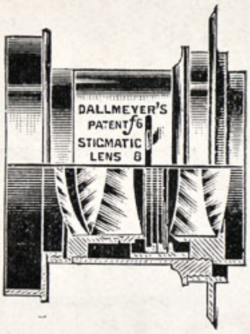

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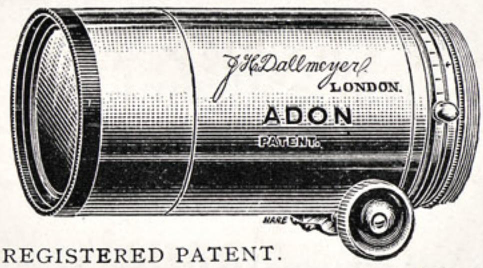

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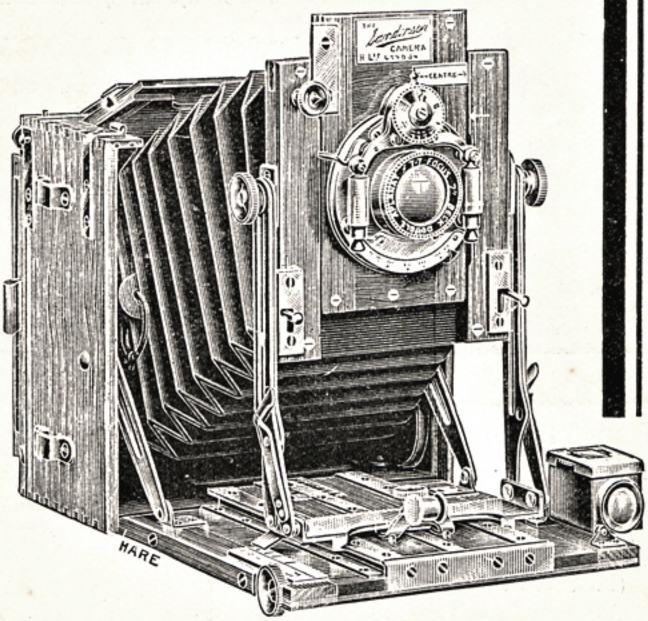

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