RODINAL

FILM DEVELOPER

ITS USES IN MINIATURE PHOTOGRAPHY

an important reprint from

LEICA PHOTOGRAPHY

(Issue No. 1—1957)

THE MAGAZINE ON MINIATURE PHOTOGRAPHY

Variable Dilution of Rodinal and its Uses in Miniature Photography

BY DIPL.-ING. H. SASSMANN

Since its introduction in 1891, Rodinal, a highly concentrated Agfa rapid developer based on the developer substance p-aminophenol, has been recommended for use, at high dilution, as a negative developer. Already at that time it was recognized how easy it was to vary the effect of p-aminophenol developers simply by varying the dilution at which they are used. The negative contrast of any given film can be varied within wide limits, and without loss of emulsion speed, merely by varying the quantity of water added to the concentrated solution—and this is a quality which no other developer substance has yet exhibited to the same degree. Over the years, the degree of dilution of Rodinal developer was progressively increased, so it is only recently that the very interesting relationship between degree of dilution, negative contrast, fog level, utilization of emulsion speed and sharpness of image contour have come generally to be recognized. This has led to the increasing use of highly dilute rapid developers in miniature developing technique. The use of Rodinal at high dilution became standard practice in miniature photography, and it gave rise to a new developing technique called "one-time" development because of its extremely favourable dilution properties.

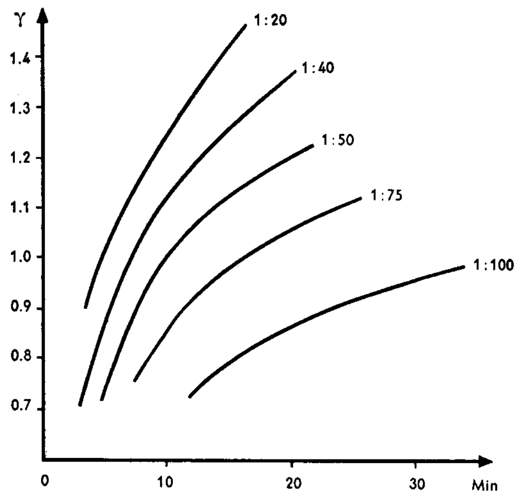

Fig. 1: Rodinal. Dependence of negative contrast on development time at various dilutions. Gamma curve gets progressively flatter at higher dilutions without much displacement along abscissa, showing that Rodinal at high dilutions yields much softer negatives without undue prolongation of development times.

Dependence of negative contrast on developer concentration

It is well known that the degree of contrast ($\gamma\infty$) obtainable is not purely a constant for the emulsion —it is also largely dependent on the composition of the developer. The rate at which $\gamma\infty$ is reached for a given emulsion is dependent on the type of developer used, and the absolute value obtainable is also very considerably dependent on the developer substance employed. Nor is it only the nature of this substance, or the ingredients with which it is used, or the alkalinity of the solution, which influence the sensitometric maximum density attained. The degree of dilution of a developer solution also influences the result. In all cases, any given developer solution used at higher dilution develops more slowly, and in terms of absolute contrast obtainable—that is, gamma infinity, irrespective of the time taken to reach it—the value reached with a dilute solution is lower than the value obtained with the same developer at higher concentration. But for different developer substances the effect of dilution varies considerably, as can be seen from the gamma, time curves of figs. 1—4. P-aminophenol, as used in the composition of Rodinal, exhibits the great dependence of contrast on the degree of dilution without appreciably slowing up the rate of development; while

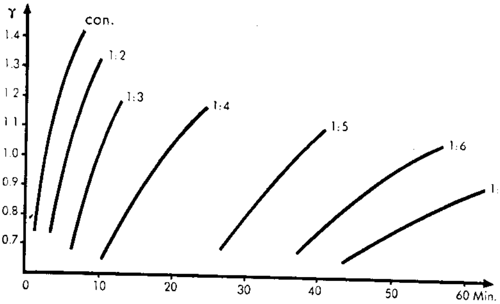

Fig. 2: Developer No. 2: metol 1.25 g/l, hydroquinone 0.4 g/l, Na_2SO_3 sicc. 20.0 g/l, Na_3PO_4 20.0 g/l. Great displacement of gamma, time curves along abscissa with very little lowering of negative contrast up to a dilution of 1:5. High fog level una voidable.

other developer substances at high dilution develop much more slowly without appreciably flattening the gamma, time curve (MQ developer in fig. 2 and Metol-Sulphite developer in fig. 4). The Metol-Sulphite-Sodium Carbonate developer of fig. 3 is fairly closely comparable with the Rodinal developer of fig. 1 if one ignores the complete depression of the gamma-time curve at dilutions greater than 1:4.

Dilution and Utilization of Emulsion Speed

Modern negative development aims at reaching a constant contrast factor (gamma value) which will enlarge easily and preserve normal gradation in the print. If we dilute a negative developer, it follows from what has been said that the constant gamma value aimed at can be reached by prolong-

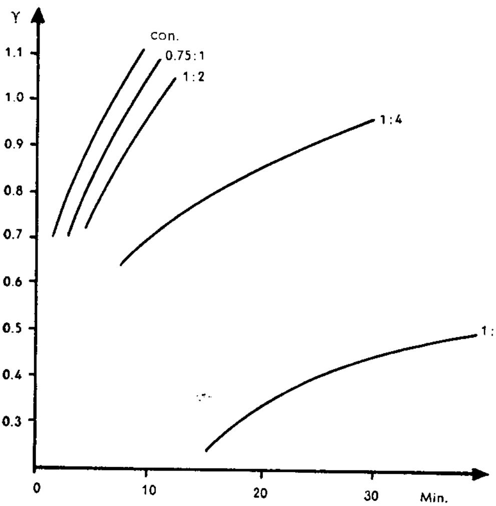

Fig. 3: Developer No. 3: metol 2.0 g/l, Na_2SO_3 sicc. 10.0 g/l, Na_2CO_3 sicc. 10.0 g/l. Great dependence of negative contrast on dilution.

ing the duration of development. But in most cases there is a concomitant loss of available emulsion speed. If we now note the behaviour of various developers at different dilutions by comparing their gamma curves and their sensitivity curves by reference to their dependence on development times, we see (figs. 1a—4a) that there is considerable variation in the degree of that dependence. Where Rodinal, as we have seen, yields increasingly flatter gamma, time curves as dilution is increased, and at the same time exhibits only a relatively gradual displacement of the sensitivity curve (figs. 1 and 1a), the sensitivity curves of the other developers tested are very rapidly displaced. In comparison with Rodinal they require development times between 30 and 60 minutes to reach a given sensitivity at high dilution. Or, to put it another way, where the attainable sensitivity

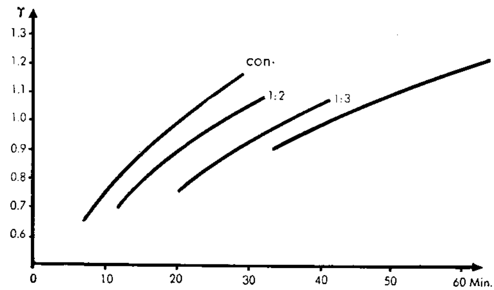

Fig. 4: Developer No. 4: metol 12.0 g/l, Na_2SO_3 sicc. 90.0 g/l, $Na_2S_2O_5$ 9.0 g/l. At various dilutions the gamma, time curves remain almost parallel, hence no possibility of adapting this developer.

(utilization of film speed) for a given gamma value does not decrease when Rodinal is used at increasingly higher dilutions—with slow hard-gradation negative film the sensitivity actually increases—the other developers exhibit a rapid decrease in utilization of available sensitivity. Between the extreme cases showing the effects of dilution in figs. 1 (1a) and 4 (4a) there are, of course, gradual transitions from one state of affairs to the other, which can be brought about by varying the composition of the developer solutions. But as yet no combination of developer substances or ingredients has been found, on which the effects of dilution are more favourable than with p-aminophenol as used in the Rodinal formula.

Dilution and fog

If we now determine the fog levels of the four developers named above, and at varying dilutions to reach a given gamma on a given negative material, it will clearly be seen that, in the case of Rodinal,

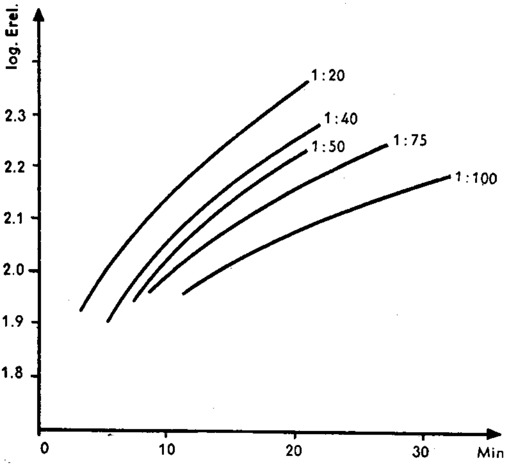

Fig. 1a: Rodinal. Dependence of relative sensitivity on development times at various dilutions. The curves flatten gradually, which means that it is simple to obtain same utilization of emulsion speed at high dilutions without undue prolongation of development time.

the fog values decrease as concentration decreases, while in the other cases fog level remains approximately constant (Developers 3 and 4), or sometimes increases very rapidly (Developer 2). Accordingly, Rodinal becomes increasingly free of developer fog the lower the concentration at which it is used. This is in sharp contrast with certain MQ formulae, in which the tendency to fog increases rapidly to a value exceeding the maximum tolerable level as dilution is increased. Although fog incidence is due to some extent to the nature of the emulsion, the manufacturers of these developers are obliged to add relatively large quantities of anti-foggants to their products in order to keep developer fog within tolerable limits. But since additions of this kind more or less strongly reduce emulsion speed, they are at pains not to add too much anti-foggant to the formula. In the nature of things, such developers cannot, like Rodinal, be used at variable dilutions to suit an emulsion or a subject photographed, because the fog level rises rapidly as dilution is increased, and this despite the measures adopted to restrict it.

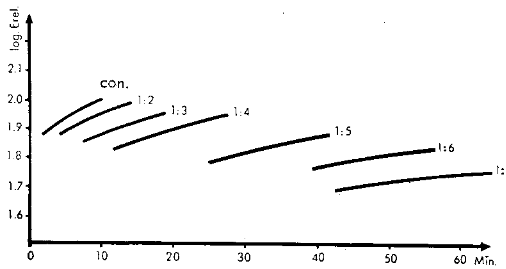

Fig. 2a: Developer No. 2. As dilution increases development times become inordinately long and there is very poor utilization of emulsion speed.

Developer Concentration and Contour Sharpness

We have seen that Rodinal is a developer which can be adapted simply by diluting it with water and in contrast with other developers it has the best utilization of emulsion speed and lowest fog level also when dilution is high. A question which might be asked is: why work at high dilutions and relatively long development times, when the same negative contrast at the same—or even better—utilization of film speed, can be obtained more quickly in a concentrated solution? The reason is to be found in the better image quality obtainable by this procedure. Highly diluted rapid developers yield negatives of the highest contour sharpness or acutance because of their very slow development of the latent image in the depth of the emulsion, and in the case of p-aminophenol the image structure is also very fine-grained. In consequence of the slow build-up of the image, developers of this kind have a strongly compensating effect and allow considerable latitude in the development of all kinds of emulsions.

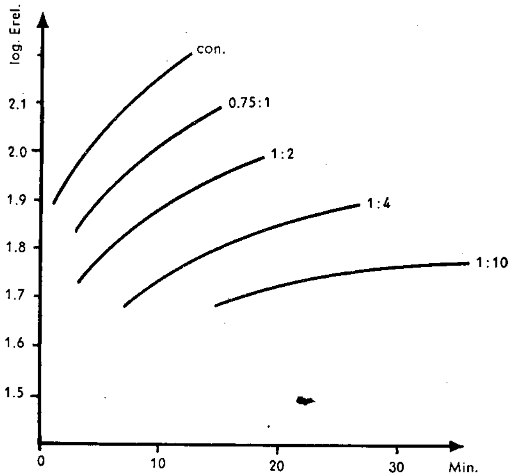

Fig. 3a: Developer No. 3 shows itself to be adaptable for use at varying dilutions, but compared with Rodinal there is considerable loss of emulsion speed.

Keeping quality and economy of highly diluted developer solutions

All developer substances, since they are all more or less powerful reducing agents, are subject to

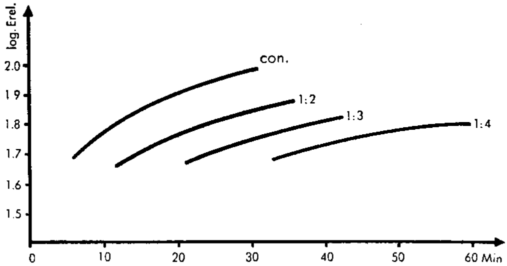

Fig. 4a: Developer 4 exhibits progressively poorer utilization of emulsion speed at increasing dilution, and there is also a great increase in the times of development at high dilutions.

oxydation by the oxygen content of the air. The sodium sulphite always present in compounded solutions merely acts as a brake on aerial oxydation, but cannot entirely prevent it. Very similar reactions are brought into play during the course of development by the reduction of silver halide into the metallic silver of the image. In practice developers are oxydized in both these ways and decompose into oxydation products which lack the power to develop. It follows that the useful life of a developer, under otherwise constant conditions, will be much shorter the lower its original concentration. Highly diluted developer solutions have little or no storage life, so any technique of developing which postulates the use of developers at very low concentration, must be confined to dish or small tank development. That is why very small quantities of concentrated solution can be used at high dilution at very low cost and be discarded after first use. Since the costs are low one suffers no loss by discarding the developer before it is worked to exhaustion, and one gains the advantage of knowing that each time a new film is developed in fresh solution the desired gamma can be reached through abiding by a set procedure. Since reputable manufacturers of developers test all their raw materials to insure constant conditions of manufacture, the results obtained with such developers show consistency of the highest order.

Discussion of the tests

For Rodinal and three other developers used in miniature technique, gamma increment and log relative sensitivity for various dilutions have been plotted against the time of development as shown in figs. 1—4 and 1a—4a. Agfa Isopan FF film was used for all these tests, but it is worth noting that the corresponding curves for Isopan F and Isopan ISS are very similar, being influenced in the same way at comparable dilutions, though we lack the space here to duplicate the diagrams.

For better graphic illustration of the effects of dilution in the four developers, and for greater ease of comparison, figs. 5 and 6 are derivative curves illustrating attainable gamma values for constant utilization of emulsion speed, and relative sensitivity or speed utilization of each developer for constant gamma, in both cases by reference to the degree of dilution. To facilitate comparison at each degree of dilution, the dilution figures are expressed as a ratio of one part concentrated solution to the number of parts of water added for each state, and for Rodinal the lowest usable dilution ratio 1:20 has been taken as equivalent to a concentrated working-strength solution of this developer, so that, for instance, an actual dilution of the concentrate in the ratio 1:100 represents a 1:5 dilution of the working-strength Rodinal developer. Relative sensitivity is expressed in numbers corresponding to the relative log E values of figs. 1a—4a—the numerical equivalents thus providing direct percentage comparison—while the gamma values are derived from the group of curves illustrated in figs. 1—4.

Since the speed utilization of the tested developers varies, it was necessary in fig. 5 to plot each derivative curve at correspondingly different levels of sensitivity in order so to obtain a uniformly accurate picture of the relative efficiency of each developer at all states of dilution up to a ratio of 1:5. For instance, we obtain a gamma of 0.8 with working-strength Rodinal diluted 1:5 (actual dilution of concentrate being 1:100) at a sensitivity of 100, but with the metol-sulphite developer No. 4, at dilution 1:4, the sensitivity is only 63—which is nearly 40% less. From fig. 6, in which variations in utilized emulsion speed at constant gamma are plotted, we see that developer No. 3 in the concentrated form has greatest utilization of emulsion

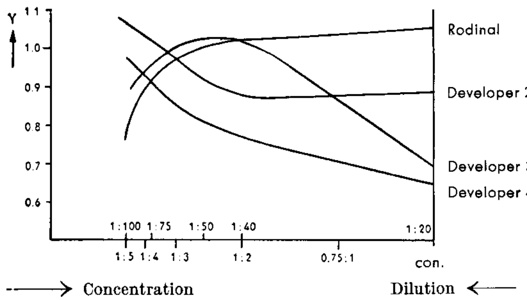

Fig. 5: Attainable gamma values at constant utilization of emulsion speed relative to dilution. Relative sensitivity for Rodinal = 100, Developer 2 = 75, Developer 3 = 80, Developer 4 = 63. It is apparent that only Rodinal is able to reach given values of sensitivity as negative contrast gets softer, hence it is an ideally adaptable developer.

speed, but that the same negative contrast or gamma for increasingly dilute solutions of this developer is obtainable only by sacrificing progressively greater margins of film speed. The MQ developer No. 2, and the metol-sulphite developer No. 4, behave in a very similar manner. With Rodinal, however, the same gamma is reached at higher dilutions with progressively better utilization of film speed than is the case with more concentrated solutions. The rise of the Rodinal sensitivity curve in fig 6 corresponds with the rapid fall of the Rodinal γ-curve in fig. 5, and in both cases the progress of these curves is in a direction opposite to the progress of the related

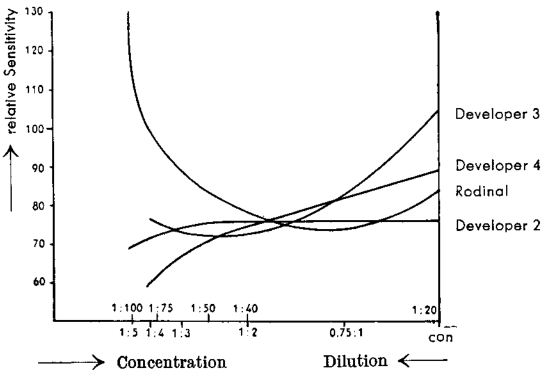

Fig. 6: Attainable utilization of emulsion speed at constant negative contrast relative to dilution. The greater the dilution of Rodinal the higher the sensitivity reached. Hence dilution can be adapted to suit the gradation of the film used: for Isopan FF 1:100, for Isopan F 1:75, and for Isopan ISS 1:40.

curves for the other developers. In the case of developer No. 3 we also notice a slight fall in gamma values at higher dilutions (fig. 5), but the rate of fall is by no means sufficient to allow this developer to be classified as an adaptable developer, that is, one that can be adapted by simple dilution to suit varying degrees of negative or subject contrast—as is the case with Rodinal.

Conclusion

We have seen that highly dilute negative developers offer advantages in miniature photography in respect of definition and graininess. There are many ways of manufacturing developer solutions which retain sufficient effectiveness at high dilution. But from our tests of four developer types we have also seen that variable dilution does not of itself confer on all developers the same degree of adaptability as it does on those based on p-aminophenol, unless one is prepared to put up with great loss of emulsion speed or with high fog incidence.

The positive value of variable dilution is proved only in the case of a p-aminophenol developer which, as Agfa Rodinal, has been available to photographers for more than 60 years. Pushing the dilution of the concentrate as far as 1:100 is a recent recommendation which further extends the universal uses, and the already great adaptability of this developer.

Rodinal makes possible the development of negatives exposed to every subject contrast range met with in practical photography. It does so with maximum utilization of emulsion speed (even when exposures are so short that they border on underexposure), since by varying the dilution it is possible to adapt the concentration of Rodinal to suit all luminance ranges, from exposures in mist to exposures in extreme back light. In each case the negatives are of best enlarging quality, and this is true not only of slow films, but applies with equal validity to films in the medium and high-speed categories. Rodinal is thus a highly adaptable universal negative developer having maximum photochemical yield throughout a range of variable dilutions.