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section can be made. As shown in Section I of this paper, an effect of the kind observed should occur only in case the cross section for loss of the final quantum of vibration is of the order of magnitude of 10^{-5} times the cross section for the collision of the second kind with metastable Hg. The latter cross section may be comparable to the gas kinetic cross section, or even somewhat larger, but it is very unlikely that it is larger by a factor as great as 10^2. This rough argument indicates that the cross section in question is of the same order of magnitude as some of the smaller cross sections found for similar processes by the dispersion of sound method.

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The Effect of Concentration on the Production of the Latent Photographic Image by Hydrogen Peroxide

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Much of the density previously reported as produced by short immersions of photographic plates in aqueous solutions of hydrogen peroxide was found to have been produced during the washing interval between exposure and development. Data are presented concerning the production of the latent image by various concentrations of hydrogen peroxide. Analysis of this data suggests that, initially, the net reaction is of the second order. An optimum concentration for the production of maximum density was indicated.

MANY substances have been reported as producing latent images when placed near or in contact with photographic emulsions. Radioactivity, phosphorescence and thermal fogging furnish satisfactory explanations in many cases. In many others, the action is due to the presence or formation of at least traces of hydrogen peroxide.[1] For this reason and because of its own intrinsic interest, especially its bearing on the problem of the mechanism of latent image formation, the fogging action of hydrogen peroxide has been the subject of much investigation.

In practically all the early work,[2–4] photographic plates were exposed to hydrogen peroxide vapor. In previously reported work where plates were immersed in aqueous solutions of hydrogen peroxide,[5, 6] they were washed for 30 minutes before development. We find that much of the density observed was produced during this washing period. Among other studies employing this technique, Sheppard and Wightman[5] made some tests with the same time of immersion for different concentrations and concluded that the effect of increasing concentration was similar to that of increasing light intensity. Further investigation along somewhat similar lines, but substituting a 1–2 second rinse for the 30 minute washing interval, has been carried out in this laboratory. Plates so briefly rinsed inevitably carry along some hydrogen peroxide into the developer. However, in agreement with observations of Wightman, Trivelli and Sheppard,[7] tests showed that negligibly little additional density was produced by the presence of small quantities of hydrogen peroxide in the developer.

The first group of tests was performed with ten concentrations ranging by geometrical progression from 3 percent to 3/512 percent and immersions, also in geometrical progression, from 1 second to 128 seconds. Portions of Eastman "33" plates were immersed for measured intervals in hydrogen peroxide of a given concentration, rinsed 1–2 seconds in water, developed 5 minutes in a pyro-soda formula, rinsed in 1 percent

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[4] Dombrowsky, Inaug. Dissert., Leipzig (1908).
[5] Sheppard and Wightman, J. Frank. Inst. **195**, 337 (1923).
[6] Jones and Blair, J. Frank. Inst. **218**, 29 (1934).
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acetic acid, fixed, washed and dried in the usual manner. Operations were carried out at 21°C.

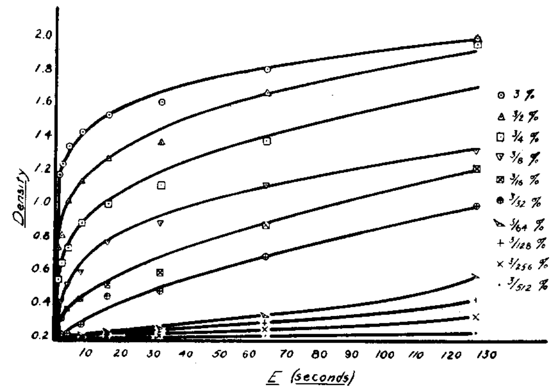

FIG. 1. Early stages of the process, showing the growth of developable density with time of exposure (immersion) in aqueous hydrogen peroxide of the stated concentrations.

The densities produced have been plotted against time of exposure (immersion) in Fig. 1.

The slopes of the density-time of exposure curves were determined from Fig. 1 at densities of 0.3, 0.4, 0.6, 0.8 and 1.0. The logarithms of these slopes were then plotted as a function of the logarithm of the concentration of hydrogen peroxide. For each density, straight lines were drawn following the trends of points thus determined. The slopes of these latter lines, interpreted as the order of the net reaction, were found to be 1.74, 1.56, 1.41, 1.14 and 0.97, respectively, for the densities in increasing order as mentioned above. Extrapolation of these results back to the density, 0.2 of a fixed-out, unexposed plate suggests that the reaction is initially of the second order. The decrease of the apparent order of the net reaction with increasing density is probably due, in part at least, to a reverse reaction causing developable grains to become undevelopable. Presumably the process is complicated by the conditions of diffusion of the hydrogen peroxide into and within the emulsion and its adsorption thereby. Dombrowsky,[4] it may be noted, found a definite tendency toward surface images when plates were exposed to hydrogen peroxide vapor for short intervals.

Other tests were carried on to solarization, i.e., until maximum density had been attained for the particular concentration and immersions for still longer intervals began to yield decreasing densities. The results are presented in Fig. 2 from which it is evident that the intermediate concentration of $\frac{3}{8}$ percent hydrogen peroxide produced a higher maximum density than either extreme, 3 percent or 3/512 percent. Another series of observations was then made to determine the maximum developable densities produced by each of the same ten concentrations with which Fig. 1 is concerned. The fact that plates of different emulsion number were used in all three of these series of tests minimizes the significance of too close, direct comparison, as has been emphasized in a previous paper.[6] However, the magnitude of the maximum density attained was found to increase, with

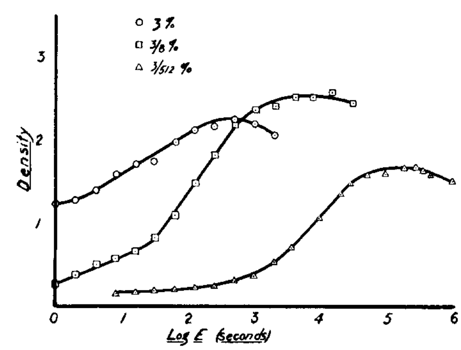

FIG. 2. Full range of exposure showing beginning of solarization and indicating an optimum concentration for the production of maximum density. Densities are plotted against logarithms of exposures (immersions).

increasing concentration, from 1.5 with 3/512 percent hydrogen peroxide up to 3.0 with the $\frac{3}{4}$ percent solution. Beyond this, it began to decrease with further increase of concentration, thus confirming the implication of Fig. 2 that there is an optimum concentration for the production of the latent photographic image by hydrogen peroxide in aqueous solution.

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