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HIGH-CONTRAST PHOTOGRAPHIC SILVER CHLORIDE EMULSIONS AND METHOD OF PROCESSING

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This invention relates to photography, and more particularly, to high-contrast silver chloride emulsions and to a method of processing such emulsions.

In the graphic arts field, where it is desired to make photographic reproductions of line and half-tone materials, it is customary to employ emulsions having a high gamma or extreme contrast. For this purpose, photographic silver chlorobromide emulsions are generally employed, in which the silver chloride content is at least about 60 mole percent. For producing such emulsions, it has been generally thought that developers containing only minute amounts of sulfite ion could be employed. See J. A. C. Yule—"Journal of the Franklin Institute," Vol. 239 (1945), pages 221-230.

Development of high-contrast chloride emulsions, as outlined above, is believed to proceed catalytically. Such development is commonly referred to in the graphic arts field as "infectious development." Since it has been heretofore thought that only small amounts of sulfite ion can be present to provide the afore-mentioned catalytic development, it has been customary to employ sodium formaldehydebisulfite in the developer, with no alkali metal sulfite, as such, being used. Alternatively, it has been a practice to form the sodium formaldehydebisulfite in situ by employing a mixture of formaldehyde and sodium sulfite in the developer.

However, developers containing such small amounts of the sulfite ion have been found difficult to handle in practice, in that erratic results are obtained, depending upon the period of time air has been in contact with the surface of the developer.

We have now found a means of obtaining excellent half-tone reproductions, wherein high-contrast chloride emulsions of a particular type are employed in combination with developers having a higher concentration of sulfite ion than is customary in the art.

Accordingly, it is an object of our invention to provide a method of obtaining high-contrast, half-tone reproductions using photographic silver chloride emulsions. Another object is to provide photographic developers for processing such high-contrast emulsions wherein the concentration of sulfite ion is higher than customary in the graphic arts field. Other objects will become apparent from a consideration of the following description and examples.

We have found that photographic silver chloride emulsions containing at least 85 mole percent of silver chloride can be processed in photographic developers containing up to about 0.05 mole of a water-soluble sulfite, such as sodium sulfite, potassium sulfite, etc.

The silver chloride emulsions employed in our invention must contain at least 85 mole percent of silver chloride. The emulsions can contain from about 85 to 100 mole percent of silver chloride, although we have found

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that emulsions containing from 5 to 15 mole percent of silver bromide are especially useful. We have further found that these emulsions can contain a small amount of silver iodide, such as 1 to 2 mole percent.

The amount of sulfite ion which can be tolerated in the developers of our invention varies from about 0.01 to about 0.05 molar. Instead of using a sulfite for the purpose of stabilizing the developer, other antioxidants, such as 8-hydroxyquinoline, ascorbic acid, phloroglucinol, β -hydroxyethylhydrazine, amino-phenols (e.g., N-methyl-p-aminophenol, etc.), meta-substituted polyphenols, pyrazolidones (e.g., 3-phenylpyrazolidone, etc.), etc., can be employed. Sodium sulfite is particularly useful in practicing our invention.

In addition to the above-mentioned antioxidant, the developers employed in our invention can contain a hydroquinone compound as the active developing agent. Such compounds include hydroquinone, isopropylhydroquinone, methylhydroquinone, 2,5-dimethylhydroquinone, etc. In general, the developer can contain from about 12 to about 20 g./liter of the hydroquinone developing agent.

The developers employed in our invention should be strongly alkaline, i.e., should have a pH of at least about 9.0, although a pH of at least 9.6 has been found to provide especially useful results. The pH of the developer can be adjusted by using a mixture of from about 70 to 80 g./liter of sodium carbonate monohydrate and from about 10 to 50 g./liter of sodium bicarbonate. Other inorganic alkaline materials, such as sodium hydroxide, sodium acetate, etc., can be employed, if desired.

Advantageously, the developer can contain a small amount of a restrainer, such as potassium bromide, sodium bromide, etc. Generally from about 3 to 5 g./liter of restrainer are quite adequate. If desired, the developer can also contain other addenda, such as sequestering agents, e.g., tetrasodium pyrophosphate, etc. The developer generally can contain sodium formaldehydebisulfite, and we have found that from about 50 to 70 g./liter of sodium formaldehydebisulfite to be quite adequate. If it is desired to make a developer suitable for dry packaging, generally no sodium formaldehydebisulfite should be employed in the same packaging unit as the alkaline material. In general, two separate units can be used, with sodium formaldehydebisulfite and the developing agent in one package, and the alkaline material in a separate package.

The chloride emulsions of our invention provide a gamma, in some instances, as high as 11 to 14. The contrast gradient is sometimes as high as 9.0 to 9.2. The contrast gradient is a figure obtained from the characteristic curve of the emulsion by drawing a line from a point on the curve 0.10 density above gross fog to a point on the curve 0.4 log E units to the right of the first point. Thus, the contrast gradient is a gradient over a 0.4 log E exposure range, and includes a part of the toe of the curve.

The effectiveness of the new photographic elements of our invention and their use in combination with the above-described developers can be measured by exposing the emulsions to a half-tone image. After developing the exposed element, the pattern consists of areas commonly referred to as shadow dots and areas known as highlight

areas. Intermediate between these two extremes are areas of varying size. The common method in the art for measuring the quality of the reproduction is to examine the shadow dot areas and the area referred to as 50% dots (i.e., $\frac{1}{2}$ clear and $\frac{1}{2}$ developed density). The quality of the shadow dots can be expressed on any convenient scale, but for the purposes of our invention, we prefer to grade on a scale where "a" is excellent and "g" is extremely poor, with varying degrees of quality proportionately graded between these two points. The quality of the 50% dots can conveniently be expressed in a progressive scale where "9" is excellent and "1" is extremely poor. A reproduction graded "6c" is considered acceptable in dot quality. A shadow dot quality below "c" is generally not acceptable and a 50% dot quality below "6" is generally not acceptable.

The following examples will serve to illustrate further the advantages obtained according to our invention. The

times indicated in the developers identified in the following table. The developed coatings were fixed in a conventional thiosulfate fixing bath and immersed in an etch bath for a period of time sufficient to obtain optimum dot quality. The etch bath employed was prepared as follows:

Solution A.—60 g. of thiourea and 2800 g. of sodium thiosulfate were dissolved in 2 liters of water at 50–60° C. and then diluted to 4 liters.

Solution B.—300 g. of potassium ferricyanide were dissolved in 750 cc. of water at 50° C. and then diluted to 1 liter.

Just prior to use, 5 parts of Solution A were mixed with 14 parts of cold water, and one part of Solution B was added. The emulsion speed (relative), contrast gradient, dot quality, image hue and etching properties for each of the coatings are given in the following table. Normal image hue means a slightly warm tone.

TABLE II

Emulsion Composition		Developer	Time (Min.)	Emulsion Speed	Contrast Gradient	Dot Quality	Image Hue	Etching Properties
Chloride	Bromide							
percent	percent							
70.....	30	B	3	170	4.2	8c	Normal.....	Normal.....
80.....	20	B	2	130	7.9	9a	Sl. Black.....	Improved.....
85.....	15	B	2½	125	8.5	8b	Black.....	Good.....
90.....	10	B	2½	125	8.5	8a, b	Very black.....	Very good.....
95.....	5	B	1½	67	13.5	8b	Very black.....	Very good.....

developers used in these examples had the following composition:

TABLE I
Developer Composition
[Grams per liter]

	A	B	C	D	E	F
Hydroquinone.....	15.0	15.0	15.0	15.0	15.0	15.0
Sodium formaldehyde-bisulfite.....	50.0	50.0	50.0	50.0	50.0	50.0
Sodium carbonate.....	35.0	35.0	35.0	35.0	35.0	35.0
Sodium bicarbonate.....	22.5	27.5	32.5	22.5	22.5	27.5
Sodium sulfite.....				2.5	5.0	2.5
Potassium bromide.....	0.75	0.75	0.75	0.75	0.75	0.75
Water to make 1 liter pH.....	9.85	9.75	9.65	9.85	9.85	9.75

EXAMPLE 1

A series of fine-grain photographic-gelatino-silver-chlorobromide emulsions was prepared, varying the silver halide content, as shown in the following table. The method of preparing these emulsions is described in Mac-William U.S. Patent 2,756,148, issued July 24, 1956. The varying amount of bromide was obtained merely by vary-

EXAMPLE 2

A series of fine-grain photographic-gelatino-silver-chlorobromide emulsions was prepared as described in U.S. Patent 2,756,148, the emulsions having the halide content shown in the following table. The emulsions were then coated on separate transparent supports, exposed as described in Example 1 and developed in the developer identified in the table for about 2.5 minutes.

A second series of the same emulsions was coated on conventional transparent supports, exposed as described in the developers identified in the table, after the developers had been aged by standing for four hours at about 68° F. in an 8 x 10-inch tray containing 500 cc. of developer.

Each of the above coatings was fixed in a thiosulfate fixing bath.

The contrast gradient and dot quality for each of the processed coatings are shown in the following table, together with the speed loss obtained by using developers which had been aged for four hours as described. The useful tray life for each of the developing solutions is also indicated in the table.

TABLE III

Emulsion Composition		Developer	Contrast Gradient	Dot Quality (Shadows)	Useful Tray Life, hours	Speed Loss in 4 Hrs.
Chloride	Bromide					
Percent	Percent					Percent
70.....	30	A	4.2	c	3	40
70.....	30	E	2.8	e	12	7
95.....	5	E	8.1	b	12	7

ing the amount of soluble bromide salt combined with the silver nitrate.

The separate batches of emulsions were then coated on a conventional film support, such as cellulose acetate or polystyrene, and the coatings dried in the usual manner. A magenta contact screen was then placed over one-half of each of the coatings and the coatings were exposed to a step wedge using tungsten illumination. The method of using such contact screen is described in "How To Use the Kodak Magenta Contact Screen," Kodak Pamphlet No. Q-21, 1956. The coatings were then developed for the

EXAMPLE 3

A fine-grain, gelatino-silver-chlorobromide emulsion containing 90 mole percent of the silver as chloride and 10 mole percent as the bromide, was prepared according to the method of U.S. Patent 2,756,148. The emulsion was then divided into two separate batches. One batch was sensitized with a sulfur sensitizer, as described in Sheppard U.S. Patent 1,574,944, issued March 2, 1926, while the second batch was sensitized with the same sulfur sensitizer and by a gold salt, as described in Damschroder U.S. Patent 2,597,856, issued May 27, 1952, or

Yutzy et al. U.S. Patent 2,597,915, issued May 27, 1952. Each of the emulsions was then coated on a transparent support, dried, and exposed as described in Example 1 above.

The exposed coatings were then developed in the developer identified in the table for 2.5 minutes, and then fixed in a conventional thiosulfate fixing solution. The contrast, dot quality and relative emulsion speed for each of the coatings are shown in the following table.

TABLE IV

Emulsion Composition		Sensitizing	Developer	Time (Min.)	Contrast	Dot Quality	Emulsion Speed
Chloride	Bromide						
Percent	Percent						
90-----	10	Sulfur-----	C	2.5	9	8a, b	78
90-----	10	Sulfur + gold.	C	2.5	9	8b	525

EXAMPLE 4

Separate batches of gelatino-silver-halide emulsions having the composition shown in the following table were prepared, and the emulsions then sensitized with a sulfur compound of the type shown in U.S. Patent 1,574,944. The emulsions were then coated on separate supports and dried. The dried coatings were then exposed to a step wedge as described in Example 1 and developed in the developers identified in the following table for the times indicated. The coatings were then fixed as described in the above examples.

A separate series of the strips were then processed in an identical manner, except that the developers were aerated for 6 hours at 68° F. in an 8 x 10-inch tray containing 500 ccs. of developer. The strips were then fixed in the manner shown above.

The relative emulsion speeds and dot quality for each of the coatings, processed in fresh developer and in aerated developer, are shown in the following table. The development latitude to obtain optimum dot quality is also indicated for each of the coatings.

TABLE V

Emulsion Composition			Developer	Time (Min.)	Emul. Speed	Dot Quality	Developing Latitude (Min.)	Effect of Aeration	
Chloride	Bromide	Iodide						Emul. Speed	Dot Quality
Percent	Percent	Percent							
70-----	30	0	A	2½	160	7b	1¾-2½	45	5b
90-----	9	1	F	2½	520	9a, b	1½-3½	430	9a

The chloride emulsions used in our invention can conveniently be ortho-sensitized or pan-sensitized with spectral sensitizing dyes. For instance, these emulsions can be spectrally sensitized by treating with a solution of a sensitizing dye in an organic solvent. Sensitizing dyes useful in sensitizing the emulsions of our invention are described in Brooker et al. U.S. Patent 2,526,632, issued October 24, 1950, Sprague U.S. Patent 2,503,776, issued April 11, 1950, and others.

The developers described in Table I above vary in their stability, as indicated in the illustrative examples. For instance, Developer A had a useful tray life of only about three hours, while the useful tray life of Developer B was about 12 hours. If processing was carried out in a developer which had become even partially oxidized, it is apparent from the tables that serious losses of emulsion speed and dot quality were obtained.

The term "half-tone" as used in the foregoing description and in the following claims means not only conventional dot patterns but also the well-known line patterns. That is, line screens can also be employed according to the above-described process to provide the unusual effects illustrated.

The photographic emulsions used in practicing our invention are, of course, of the developing-out type.

The emulsions can be chemically sensitized by any of the accepted procedures. The emulsions can be digested with naturally active gelatin, or sulfur compounds can be added such as those described in Sheppard U.S. Patent 1,574,944, issued March 2, 1926, and Sheppard et al. 1,623,499, issued April 5, 1927, and Sheppard and Brigham U.S. Patent 2,410,689, issued November 5, 1946.

The emulsions can also be treated with salts of the noble metals such as ruthenium, rhodium, palladium, iridium, and platinum. Representative compounds are ammonium chloropalladate, potassium chloroplatinate, and sodium chloropalladate, which are used for sensitizing in amounts below that which produces any substantial fog inhibition, as described in Smith and Trivelli U.S. Patent 2,448,060, issued August 31, 1948, and as antifoggants in higher amounts, as described in Trivelli and Smith U.S. Patents 2,566,245, issued August 28, 1951 and 2,566,263, issued August 28, 1951.

The emulsions can also be chemically sensitized with gold salts as described in Waller et al. U.S. Patent 2,399,083, issued April 23, 1946, or stabilized with gold salts as described in Damschroder U.S. Patent 2,597,856, issued May 27, 1952, and Yutzy and Leermakers U.S. Patent 2,597,915, issued May 27, 1952. Suitable compounds are potassium chloroaurate, potassium aurithiocyanate, potassium chloroaurate, auric trichloride and 2-aurosulfo-benzothiazole methochloride.

The emulsions can also be chemically sensitized with

reducing agents such as stannous salts (Carroll U.S. Patent 2,487,850, issued November 15, 1949), polyamines, such as diethylene triamine (Lowe and Jones U.S. Patent 2,518,698, issued August 15, 1950), polyamines, such as spermine (Lowe and Allen U.S. Patent 2,521,925, issued September 12, 1950), or bis(β -aminoethyl)sulfide and its water-soluble salts (Lowe and Jones U.S. Patent 2,521,926, issued September 12, 1950).

The emulsions can also be optically sensitized with cyanine and merocyanine dyes, such as those described in Brooker U.S. Patents 1,846,301, issued February 23, 1932; 1,846,302, issued February 23, 1932; and 1,942,854, issued January 9, 1934; White U.S. Patent 1,990,507, issued February 12, 1935; Brooker and White U.S. Patents 2,112,140, issued March 22, 1938; 2,165,338, issued July 11, 1939; 2,493,747, issued January 10, 1950; and 2,739,964, issued March 27, 1956; Brooker and Keyes U.S. Patent 2,493,748, issued January 10, 1950; Sprague U.S. Patents 2,503,776, issued April 11, 1950 and 2,519,001, issued August 15, 1950; Heseltine and Brooker U.S. Patent 2,666,761, issued January 19, 1954; Heseltine U.S. Patent 2,734,900, issued February 14, 1956; Van Lare U.S. Pat-

ent 2,739,149, issued March 20, 1956; and Kodak Limited British Patent 450,958, accepted July 15, 1936.

The emulsions can also be stabilized with the mercury compounds of Allen, Byers, and Murray U.S. Patent 2,728,663, issued December 27, 1955; Carroll and Murray U.S. Patent 2,728,664, issued December 27, 1955; and Leubner and Murray U.S. Patent 2,728,665, issued December 27, 1955; the triazoles of Heimbach and Kelly U.S. Patent 2,444,608, issued July 6, 1948; the azaindenes of Heimbach and Kelly U.S. Patents 2,444,605 and 2,444,606, issued July 6, 1948; Heimbach U.S. Patents 2,444,607, issued July 6, 1948 and 2,450,397, issued September 28, 1948; Heimbach and Clark U.S. Patent 2,444,609, issued July 6, 1948; Allen and Reynolds U.S. Patents 2,713,541, issued July 19, 1955 and 2,743,181, issued April 24, 1956; Carroll and Beach U.S. Patent 2,716,062, issued August 23, 1955; Allen and Beilfuss U.S. Patent 2,735,769, issued February 21, 1956; Reynolds and Sagal U.S. Patent 2,756,147, issued July 24, 1956; Allen and Sagura U.S. Patent 2,772,164, issued November 27, 1956, and those disclosed by Birr in "Z. wiss. Phot.," vol. 47, 1952, pages 2-28; the quaternary benzothiazolium compounds of Brooker and Staud U.S. Patent 2,131,038, issued September 27, 1938; and the zinc and cadmium salts of Jones U.S. patent application Serial No. 493,047, filed March 8, 1955 (now U.S. Patent 2,839,405, issued June 17, 1958).

The emulsions may also contain speed-increasing compounds of the quaternary ammonium type of Carroll U.S. Patent 2,271,623, issued February 3, 1942; Carroll and Allen U.S. Patent 2,288,226, issued June 13, 1942; and Carroll and Spence U.S. Patent 2,334,864, issued November 23, 1943; and the polyethylene glycol type of Carroll and Beach U.S. Patent 2,708,162, issued May 10, 1955.

The emulsions may contain a suitable gelatin plasticizer such as glycerin; a dihydroxy alkane such as 1,5-pentane diol as described in Milton and Murray U.S. application Serial No. 588,951, filed June 4, 1956; an ester of an ethylene bis-glycolic acid such as ethylene bis(methyl glycolate) as described in Milton U.S. application Serial No. 662,564, filed May 31, 1957; bis(ethoxy diethylene glycol) succinate as described in Gray U.S. application Serial No. 604,333, filed August 16, 1956, or a polymeric hydrosol as results from the emulsion polymerization of a mixture of an amide of an acid of the acrylic acid series, an acrylic acid ester and a styrene-type compound as described in Tong U.S. patent application Serial No. 311,319, filed September 24, 1952 (now U.S. Patent 2,852,386, issued September 16, 1958). The plasticizer may be added to the emulsion before or after the addition of a sensitizing dye, if used.

The emulsion may be hardened with any suitable hardener for gelatin such as formaldehyde; a halogen-substituted aliphatic acid such as mucobromic acid as described in White U.S. Patent 2,080,019, issued May 11, 1937; a compound having a plurality of acid anhydride groups such as 7,8-diphenylbicyclo(2,2,2)-7-octene-2,3,5,6-tetracarboxylic dianhydride, or a dicarboxylic or a disulfonic acid chloride such as terephthaloyl chloride or naphthalene-1,5-disulfonyl chloride as described in Allen and Carroll U.S. Patents 2,725,294 and 2,725,295, both issued November 29, 1955; a cyclic 1,2-diketone such as cyclopentane-1,2-dione as described in Allen and Byers U.S. Patent 2,725,305, issued November 29, 1955; a biester of methane-sulfonic acid such as 1,2-di-(methanesulfonyl)-ethane as described in Allen and Laakso U.S. Patent 2,726,162, issued December 6, 1955; 1,3-dihydroxy-methylbenzimidazol-2-one as described in July, Knott and Pollak U.S. Patent 2,732,316, issued January 24, 1956; a dialdehyde or a sodium bisulfite derivative thereof, the aldehyde groups of which are separated by 2-3 carbon atoms, such as β -methyl glutaraldehyde bis-sodium bisulfite as described in Allen and Burness U.S. patent application Serial No. 556,031, filed December 29, 1955; a bis-aziridine carboxamide such as trimethylene bis(1-aziridine carboxamide) as described

in Allen and Webster U.S. patent application Serial No. 599,891, filed July 25, 1956; or 2,3-dihydroxy dioxane as described in Jeffreys U.S. patent application Serial No. 624,968, filed November 29, 1956 (now U.S. Patent 2,870,013, issued January 20, 1959).

The emulsions may contain a coating aid such as saponin; a lauryl or oleoyl monoether of polyethylene glycol as described in Knox and Davis U.S. Patent 2,831,766, issued April 22, 1958; a salt of a sulfated and alkylated polyethylene glycol ether as described in Knox and Davis U.S. Patent No. 2,719,087, issued September 27, 1955; an acylated alkyl taurine such as the sodium salt of N-oleoyl-N-methyl taurine as described in Knox, Twardokus and Davis U.S. Patent 2,739,891, issued March 27, 1956; the reaction product of a dianhydride of tetracarboxybutane with an alcohol or an aliphatic amine containing from 8 to 18 carbon atoms which is treated with a base, for example, the sodium salt of the monoester of tetracarboxybutane as described in Knox, Stenberg and Wilson U.S. patent application Serial No. 485,812, filed February 2, 1955 (now U.S. Patent 2,843,487, issued July 15, 1958); a water-soluble maleopimarate or a mixture of a water-soluble maleopimarate and a substituted glutamate salt as described in Knox and Fowler U.S. Patent 2,823,123, issued February 11, 1958; an alkali metal salt of a substituted amino acid such as disodium N-(carbo-p-tert. octylphenoxypentaethoxy)-glutamate as described in Knox and Wilson U.S. patent application Serial No. 600,679, filed July 30, 1956; or a sulfosuccinamate such as tetrasodium N-(1,2-dicarboxyethyl)-N-octadecyl sulfosuccinamate or N-lauryl disodium sulfosuccinamate as described in Knox and Stenberg U.S. Patent application Serial No. 691,125, filed October 21, 1957.

In the preparation of the silver halide dispersions employed for preparing silver halide emulsions, there may be employed as the dispersing agent for the silver halide in its preparation, gelatin or some other colloidal material such as colloidal albumin, a cellulose derivative, or a synthetic resin, for instance, a polyvinyl compound. Some colloids which may be used are polyvinyl alcohol or a hydrolyzed polyvinyl acetate as described in Lowe U.S. Patent 2,286,215, issued June 16, 1942; a far hydrolyzed cellulose ester such as cellulose acetate hydrolyzed to an acetyl content of 19-26% as described in U.S. Patent 2,327,808 of Lowe and Clark, issued August 24, 1943; a water-soluble ethanolamine cellulose acetate as described in Yutzy U.S. Patent 2,322,085, issued June 15, 1943; a polyacrylamide having a combined acrylamide content of 30-60% and a specific viscosity of 0.25-1.5 on an imidized polyacrylamide of like acrylamide content and viscosity as described in Lowe, Minsk and Kenyon U.S. Patent 2,541,474, issued February 13, 1951; zein as described in Lowe U.S. Patent 2,563,791, issued August 7, 1951; a vinyl alcohol polymer containing urethane carboxylic acid groups of the type described in Unruh and Smith U.S. Patent 2,768,154, issued October 23, 1956; or containing cyano-acetyl groups such as the vinyl alcohol-vinyl cyanoacetate copolymer as described in Unruh, Smith and Priest U.S. Patent 2,808,331, issued October 1, 1957; or a polymeric material which results from polymerizing a protein or a saturated acylated protein with a monomer having a vinyl group as described in U.S. application Serial No. 527,872 of Illingsworth, Dann and Gates, filed August 11, 1954 (now U.S. Patent 2,852,382, issued July 16, 1958).

If desired, compatible mixtures of two or more of these colloids may be employed for dispersing the silver halide in its preparation. Combinations of these antifoggants, sensitizers, hardeners, etc., may be used.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

What we claim as our invention and desire secured by Letters Patent of the United States is:

1. In the reproduction of a half-tone screened pattern by exposing a photographic silver halide emulsion to a half-tone screened image and developing the resulting exposed silver halide emulsion with a photographic developer, the improvement which comprises employing a silver halide emulsion having a silver chloride content of at least 85 mole percent and a photographic developer having a pH of at least 9.0, and containing a 1,4-dihydroxybenzene compound, sodium formaldehyde bisulfite, and a restrainer, said photographic developer containing from 0.01 to 0.05 molar of sulfite ion and said silver halide emulsion having a gamma of at least 11.

2. In the reproduction of a half-tone screened pattern by exposing a photographic silver halide emulsion to a half-tone screened image and developing the resulting exposed silver halide emulsion with a photographic developer, the improvement which comprises employing a photographic silver halide emulsion containing from 85 to 95 mole percent of silver chloride, from 15 to 5 mole percent of silver bromide, from 2 to 0 mole percent of silver iodide and a photographic developer having a pH of at least 9.6 and containing from 12 to 20 g./liter of hydroquinone, from 50 to 70 g./liter of sodium formaldehydebisulfite and from 3 to 5 g./liter of a restrainer, said photographic developer containing from 0.01 to 0.05

molar of sulfite ion and said silver halide emulsion having a gamma of at least 11.

3. In the reproduction of a half-tone screened pattern by exposing a photographic silver halide emulsion to a half-tone screened image and developing the resulting exposed silver halide emulsion with a photographic developer, the improvement which comprises employing a silver halide emulsion containing from 85 to 95 mole percent of silver chloride, from 15 to 5 mole percent of silver bromide and from 2 to 0 mole percent of silver iodide and a photographic developer having a pH of at least 9.6 and containing from 12 to 20 g./liter of hydroquinone, from 50 to 70 g./liter of sodium formaldehydebisulfite, from 3 to 5 g./liter of a restrainer and from 1.25 to 5.0 g./liter of sodium sulfite, said silver halide emulsion having a gamma of at least 11.

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