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Kato et al.

[11] **3,776,696**

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[54] **LIQUID SENSITOMETRY OF PHOTOGRAPHIC EMULSION**

[75] Inventors: **Hisatoyo Kato; Hideo Takeda,** both of Minami Ashigara-Machi, Japan

[73] Assignee: **Fuji Photo Film Co., Ltd.,** Kanagawa, Japan

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[21] Appl. No.: **188,404**

[30] **Foreign Application Priority Data**

Oct. 13, 1970 Japan 45/89933

[52] **U.S. Cl.** ..... **23/230 R,** 23/253 R, 96/27 E, 96/50 R, 96/63, 96/94 R, 356/201, 356/203, 356/209

[51] **Int. Cl.... G01n 21/26,** G01n 33/00, G03c 5/26

[58] **Field of Search** ..... 23/230 R, 230 A, 23/253 R, 253 A; 96/27 E, 50 R, 63

[56] **References Cited**

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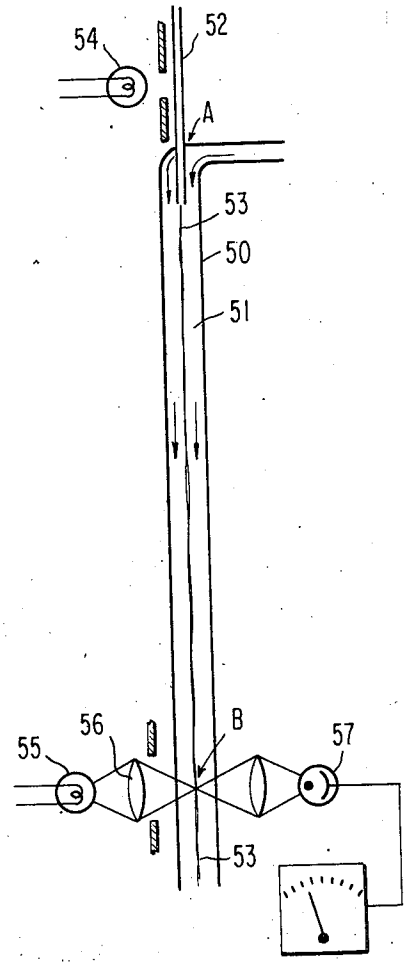
Primary Examiner—Joseph Scovronek
Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A method of performing liquid sensitometry on a liquid photographic emulsion wherein the photographic emulsion is exposed to radiation and then caused to flow in contact with a developer solution. The photographic emulsion and developer remain in distinct layers in contact with each other. During the period when the developer and emulsion flow together, the emulsion is developed by diffusion and penetration of the developer at the interface between the developer and emulsion. The optical density of the developed emulsion is continuously measured.

4 Claims, 4 Drawing Figures



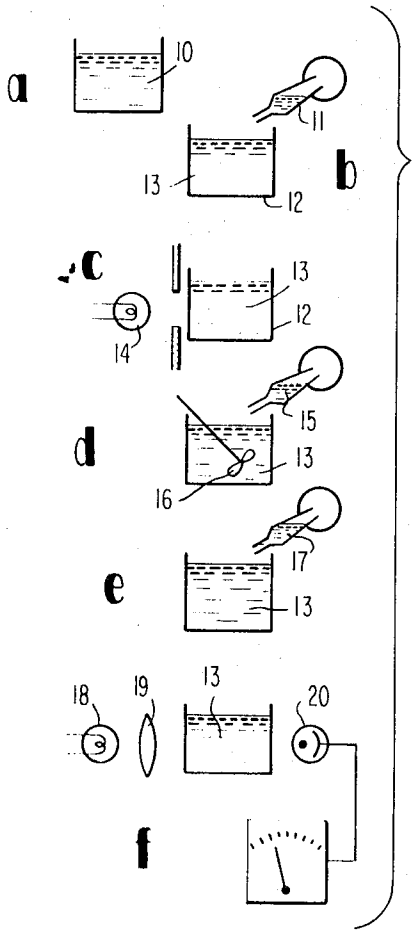


FIG. 1

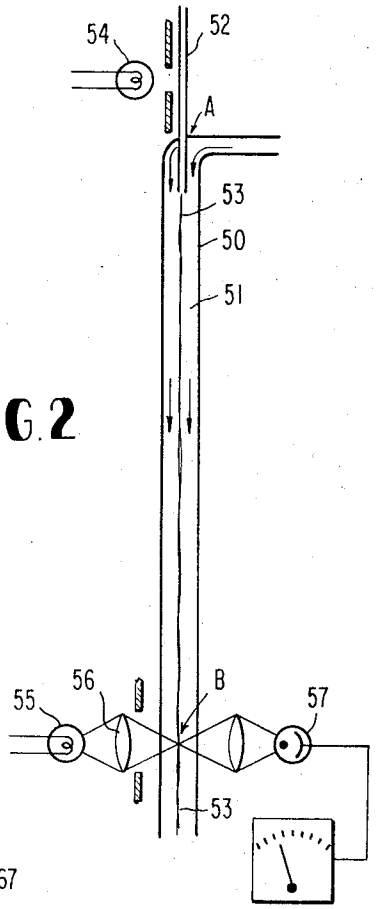


FIG. 2

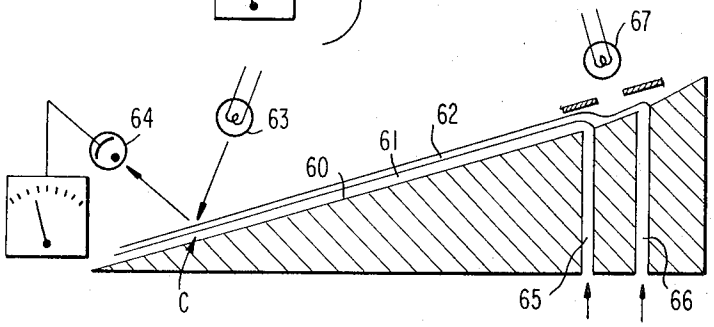


FIG. 3

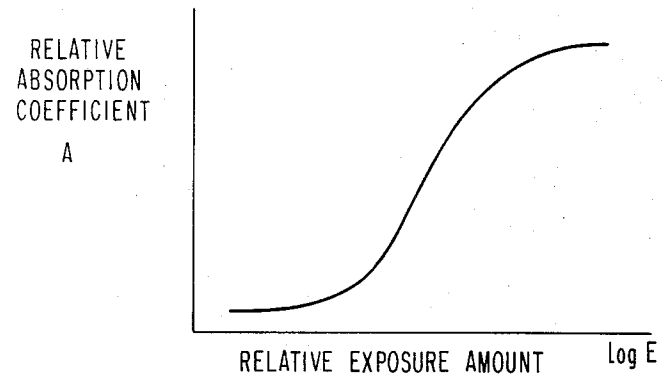


FIG. 4

LIQUID SENSITOMETRY OF PHOTOGRAPHIC EMULSION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improvement in liquid emulsion sensi-tometry of photographic emulsion in liquid state.

2. Description of the Prior Art

The ordinary sensitometry of silver halide photographic emulsion is carried out as follows:

A sample of emulsion is coated on a base support such as film paper or other fabric and dried thereon. The resulting sensitized material is cut into strips, exposed to light of graduated intensity, developed, fixed, washed and dried. The optical density of the resulting image is then measured in a demsitometer. From the data thus obtained, various photograpic characteristics of the material can be determined. However, such tests are relatively time consuming, requiring hours or even days, and thus inadquate to test and/or control the properties of emulsions by measurement of photographic characteristics during the course of manufacture. Liquid emulsion sensitometry is a rapid and simple method for determining relative densities produced upon exposure and development of photographic emulsion which is disclosed in U.S. Pat. No. 2,590,830.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved method of liquid emulsion sensitometry based on a different concept than U.S. Pat. No. 2,590,830.

An object of the invention is to provide a method of liquid sensitometry of photographic emulsion without losing advantages of the conventional liquid emulsion sensitometry.

Another object of the invention is to provide a method of liquid emulsion sensitometry for obtaining a relation between exposure and density rapidly and easily while changing the quantity of exposure (i.e., the product of the length of time of the exposure and the intensity of the radiation source).

Still another object of the invention is to provide a method of liquid emulsion sensitometry without the contamination of vessel walls.

The above objects can be attained by flowing a liquid silver halide photographic emulsion and a developer solution in such a manner that they are separated into two distinct contacting layers to diffuse and penetrate the developer solution into the liquid emulsion at the interface therebetween, whereby the liquid emulsion is developed. The optical density of the developed liquid emulsion is continuously measured.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the drawings, in which:

FIGS. 1*a* — 1f are views illustrating the conventional liquid sensitometry of photographic emulsion,

FIGS. 2 and 3 are views showing the apparatus for practical embodiments of the method according to the invention, and

FIG. 4 is a characteristic curve showing the photographic properties obtained by the method according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A conventional method of liquid sensitometry of photographic emulsion will now be described referring to FIGS. 1*a* – 1*f*.

A melted photographic emulsion **10** is measured by a measuring device **11**, and the emulsion is introduced in a transparent vessel **12** as an inspection sample **13.** Exposing the transparent vessel **12** to a light source **14,** the sample **13** is exposed in a liquid state. A prescribed quantity of developer solution **15** is added to the sample, and the resulting mixture is sufficiently stirred with an agitator **16** so as to effect development. In order to stop development at the end of the desired period, a predetermined quantity of stopping solution or fixing solution **17** is added to the sample **13,** and the optical density of the sample **13** is then measured in a densitometer, comprising a light source **18,** a collimator **19,** and a light receiver **20.** By repeating the above-mentioned operations while changing the quantity of irradiation of light, and plotting density against log exposure, a curve is obtained showing the gradation and sensitivity of emulsion.

Although this conventional method has the advantage that sensitometry of the photographic emulsion can be effected promptly and simply as compared with the ordinary sensitometry of an emulsion coated and dried on film, paper or other fabric, it has the following drawbacks.

Namely, the above-mentioned developing operations must be repeated, while varying the quantity of exposure, for determining the definite relation between the quantity of exposure and the density of emulsion, thus the total measurement is troublesome. Although a process is known in which the liquid emulsion sensitometry is carried out continuously by changing exposure by means of a flow tube, even in this case, due to the velocity distribution of flow, emulsions, which are exposed to various exposure levels and mixed with developer solution, are measured together at the density measuring point in the downstream of flow tube, so that it is difficult to obtain an accurate value of density under each exposure level when the exposure is varied rapidly and continuously.

Since photographic emulsion and developer solution are to be mixed, the wall of a vessel or a tube is liable to be contaminated by emulsion, which leads to errors in the optical measurement of density, and it is necessary to clean a vessel or a tube frequently.

FIG. 2 is an apparatus showing an embodiment of the method according to the invention. In the drawing, developer solution **51** is conducted through a tube **50** in a perfect laminar flow. A small tube **52** inserted in the upper portion A of a tube **50** and liquid emulsion **53** is extruded from tube **52** in a thread form into the central portion of the tube **50.** The liquid emulsion is conducted such that it is surrounded by the developer solution while the liquid emulsion and the dveloper solution are distinctly separated. The emulsion and the developer solution are made to flow at a predetermined constant rate of flow utilizing head pressure or a metering pump.

In such a flowing condition, development of the emulsion **53** proceeds only by diffusion and penetration of the developer solution **51** into the thread emulsion **53.**

The emulsion **53** is subjected to uniform radiation of desired intensity and wavelength in the samll tube **52.** Tube **52** comprises a material which is transparent to light of the wavelength to be employed in the exposure. The radiation is derived from light source **54** and controlled by a suitable intensity control device. Furthermore, since the thread emulsion **53** is carried in such a state that the relative position is fixed, or in a so-called piston flow, no problems arise upon mixing because of the velocity distribution of flow in the tube, when exposure is changed rapidly and continuously which occurs in the conventional method.

The quantity of silver reduced by development is determined at a density measuring point B on the downstream of the tube **50** where development proceeded for an optimum developing period which was determined previously. A beam of light from a source **55** passes through collimeter **56** and is focused on the emulsion **53** through a window of tube **50,** and the transmitted light or reflected light is measured by a light receiver **57.**

In this apparatus, since the emulsion **53** does not come in contact with the wall of the tube **50,** the tube will not be contaminated by adhesion of emulsion or the reduced silver. Therefore, there is no possibility of making errors in the optical measurement because of contamination.

Furthermore, since all the liquid is flowing, a certain time is required before blackening density appears, even when the emulsion **53** is affected by the light from a source **55,** so that the light of any wavelength does not affect the density measurement, and thus can be selected optionally.

It is difficult to prove quantitatively, but the development process of this invention is more or less similar to the development process in the coated emulsion such as in conventional photographic film or paper, in which diffusion and penetration effect appear, rather than the process in the method of U.S. Pat. No. 2,590,830. And thus, utilizing the invention, we can determine the photographic properties in the coated emulsion without a complicated processing of ordinary photographic sensitometry.

FIG. **3** is a schematic diagram of the apparatus showing another embodiment of the method according to the invention. A developer solution **61** is extruded from a discharge slot **65** onto the downwardly inclined slide surface **60** in the form of a layer, and flows down on the slide surface under the influence of gravity. Next, a liquid emulsion layer **62** is extruded from a discharge slot **66** onto the downwardly slide surface **60.** After being exposed to a predetermined quantity of illumination from a light source **67,** the liquid emulsion layer **62** flows up on top of the layer **61** of the developer solution and the two then flow together down slide surface **60** separated into two distinct layers. The optical density, due to silver reduced by development, is determined by projecting light from a source **63** on a density measuring point C where development has proceeded for an optimum predetermined developing time, and measuring the transmitted light or reflected light with a light receiver **64.**

In the case in which this apparatus is used, it can be easily understood that the device has a similar advantage as that shown in FIG. **2.**

According to the method of the invention, all kinds of liquid silver halide photographic emulsions can be measured and all kinds of developer solutions can be used for measuring the silver halide liquid emulsion. Example:

This example was carried out by using the apparatus shown by FIG. **2.**

While phenidone-hydroquinone developer (PQ developer) at 30° C was continuously supplied into a tube **50,** a high speed X-ray photographic emulsion at 30° C was extruded in a thread state from a small tube **52** into the center of tube **50.** In this case, an inner diameter of the tube **50** was 2.3 mm., a diameter of the thread liquid emulsion was 0.2 mm., and a linear velocity of the thread liquid emulsion was 3.1 cm./sec. The emulsion flowing in the small tube **52** was exposed to a light source, in which the quantity of exposure was controlled by continuously changing the density of a neutral density filter.

The thread liquid emulsion **53** and the developer **51** flowed in the direction of the arrow in such a state that the solution **51** surrounded the emulsion **53,** and the liquid emulsion was developed with the developer only by the diffusion and penetration of the developer into the emulsion.

At a point B of the tube **50,** where the developed emulsion flowed one minute after contact with the developer, a degree of light absorption (total incident light (reflected light + transmitted light + diffused light) was measured utilizing an integrating sphere. In this case, since the exposure was continuously changed with a lapse of time, the blackening optical density corresponding to the different exposure level was continuously obtained with a lapse of time. A wavelength of light for measuring the optical density was 600 mm.

A characteristic curve as shown in FIG. **4** was obtained which is the same result as in the conventional sensitometry using a photographic plate or photographic film.

While the invention has been particularly shown and described with reference to the preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. A method of performing sensitometry of a photographic emulsion comprising:

a. causing a flow of a liquid photographic emulsion;

b. exposing said photographic emulsion to a predetermined quantity of radiation;

c. causing a flow of a developer solution such that the developer solution contacts said exposed photographic emulsion and said developer solution and said exposed photographic emulsion form two distinct layers flowing at the same velocity, whereby said exposed photographic emulsion is developed by diffusion and penetration of said developer solution into said exposed photographic emulsion at the contacting surface therebetween while in the flowing condition; and

d. continuously measuring the optical density of the developed photographic emulsion while said developed photographic emulsion is in its flowing condition.

2. The method of performing sensitometry as set forth in claim **1** wherein causing the flow of the liquid photographic emulsion comprises extruding said photographic emulsion.

3. The method of performing sensitometry as set forth in claim 2, wherein said exposing of said photographic emulsion is to a continually changing quantity of radiation wherein said developer solution is caused to flow in a perfect laminar flow and wherein the photographic emulsion is extruded in the form of a thread surrounded by said developer and is in contact therewith in said distinct layers.

4. The method of performing sensitometry as set forth in claim 2, wherein said exposing of said photographic emulsion is to a continually changing quantity of radiation, wherein said developer solution is caused to flow by extruding it from a slot on an inclined surface and allowing it to flow down said inclined surface under the influence of gravity, and wherein the photographic emulsion is extruded in the form of a layer which flows on top of the extruded developer solution.

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