E. B. DOWNING.

DEVELOPMENT OF EXPOSED SENSITIZED MEDIUMS.

APPLICATION FILED MAR. 16, 1918.

1,302,777.

Patented May 6, 1919.

2 SHEETS—SHEET 1.

Fig 1.

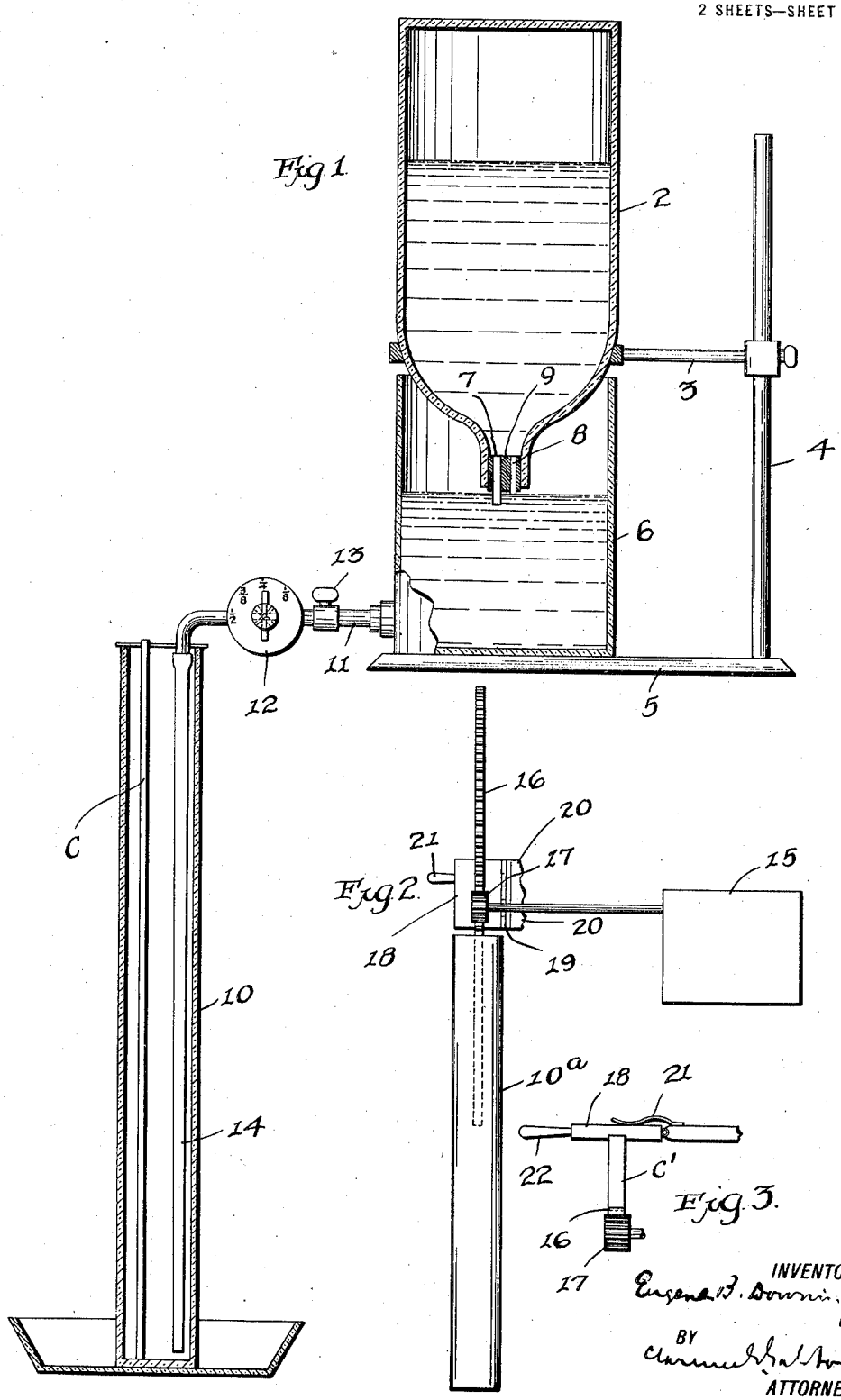


Fig 2.

Fig 3.

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2 SHEETS—SHEET 2.

Fig. 4.

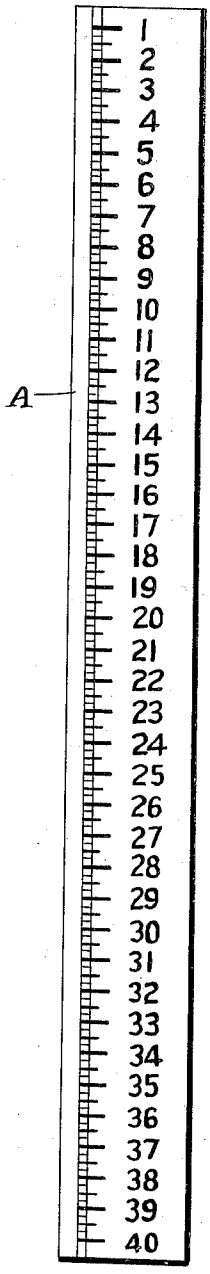


Fig. 5.

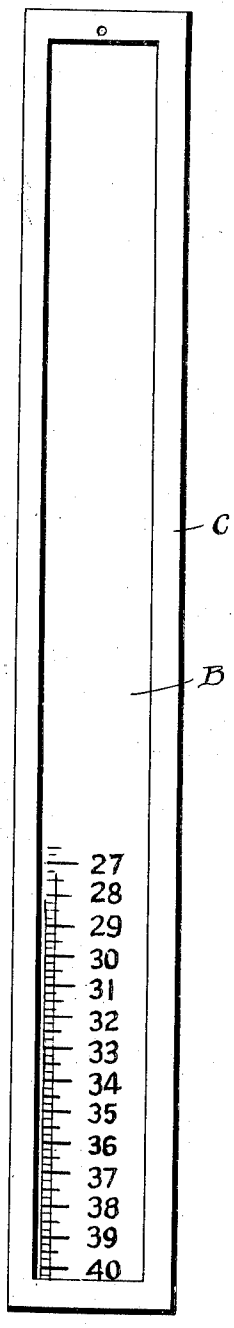
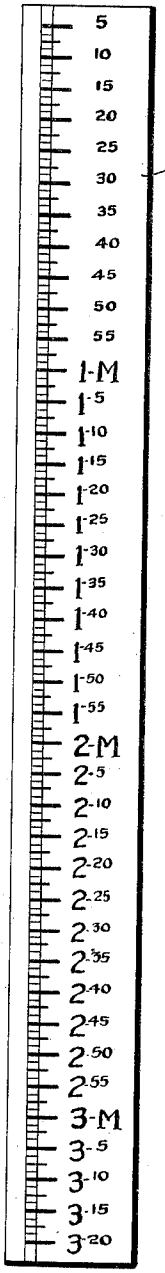


Fig. 6.



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EUGENE B. DOWNING, OF NEW YORK, N. Y.

DEVELOPMENT OF EXPOSED SENSITIZED MEDIUMS.

1,302,777. Specification of Letters Patent. Patented May 6, 1919.

Application filed March 16, 1918. Serial No. 222,817.

To all whom it may concern:

Be it known that I, EUGENE B. DOWNING, a citizen of the United States, residing in the borough of Manhattan, city of New York, county of New York, and State of New York, have invented new and useful Improvements in the Development of Exposed Sensitized Mediums, of which the following is a specification.

The invention relates particularly to the development of exposed sensitized mediums, though other features and aspects of the invention will be alluded to hereinafter. In developing such mediums, that is to say positive and negative films, positive and negative plates, etc., it is necessary that certain factors be known and strictly observed if perfect results in developing are to be secured. Some of the factors may be known, but the most important of them must be determined, and within this latter group falls the unknown value or actual working energy of various developers. Their energy cannot be determined merely by knowledge of their composition; neither can they be determined by the most expert by observation of the sensitized medium in its process of development when illuminated only by the subdued and uncertain dark room light.

In developing these mediums there is but one point of development to which they should be carried to produce the proper gradation of shade and intensity which constitutes perfect development. Any greater or lesser degree of development produces imperfect results.

To determine correct development visually by dark room light is a physical impossibility. This is especially true of motion picture films on account of the small size of the image. Consequently the results secured by the most expert dark room man are only approximately correct at best and usually the results of his efforts are no better than 65 to 70% perfect. Thus, in the case of a film upon which thousands of dollars have been carefully spent to produce a work of art and beauty, from 15 to 50% of the perfection already attained is usually lost in the dark room by imperfect development. Furthermore, the exaggerated contrasts in densities and lack of proper gradations and softness of tone cause strains to the eyes and nerves of thousands and millions of persons who may view the work upon the screen.

It is, therefore, of the greatest importance that some method and means be provided for accurately ascertaining the working energy of developing solutions and the actual time required to produce 100% perfectly developed films and plates.

A developer may be known to be of a certain strength and of any of the known standard developing agents, but its actual working energy at any particular time will remain unknown, as many things influence the activity of developers, such as changes of temperature, use, age, alkali, etc., so that the working energy of any developing solution is constantly liable to change; consequently the time for correct and perfect development is correspondingly subject to change. For example, in the case of a certain developing solution I have secured a perfectly developed film in eight minutes and forty seconds at a temperature of 60° F. With the same solution without any other change than a rise of temperature to 68½° F. perfect development was secured in exactly four minutes and five seconds. Thus the working energy of the developer was increased more than 100% by a rise of 8½° in temperature.

The time of exposure given to a sensitized medium does not control or influence the time of perfect development of said medium in the least, but imperfect exposures, that is to say under and over exposures, do deceive the dark-room man in his visual process of development where apparent intensity is his only guide. He will invariably judge an over exposed plate or film to be fully developed before the relatively correct steepness of intensity and gradations has been attained. Consequently flatness and lack of life is the result. In the case of under-exposure his guide is again false, and for lack of normal visual density, he forces development and discounts perfection, in many cases to a total loss.

The time of correct and perfect development of a normally exposed plate or film under certain conditions is also the only time of perfect development for all classes of exposure, under exposed and over exposed included.

Under-development produces flatness, dullness and relatively imperfect and low gradations of intensities and half-tones and lacking in its relatively corresponding high lights. Over-development, however slight it may be, produces harshness, exaggerated

contrasts and a distorted scale of gradations, also serious loss of detail, unsightly dark shadows and highlights take the place of the once attained soft and harmonious tones.

Perfect development produces a harmonious scale of perfectly graduated intensities, highlights, half tones and shadows, which will in the most artistic and perfect way represent the subject photographed.

The secret of perfect developing is to know the speed or working energy of the given developer. Allow 100% to mark the point of perfection in development. The working energy of the developer having been ascertained to a degree of certainty, then by a simple calculation, we know development of our negative, for example, must continue to the last expired moment of a well defined period of time in order to attain that supreme high degree of perfection, and immediately or instantly thereupon development must cease if that perfection is retained. If not, perfection is rapidly discounted. 100% perfect development has no latitude; like a stone cast into the air, when it reaches its top most height, that point also marks the beginning of its down-fall.

It is a well known fact among earnest students of photography that with any developer when developing properly exposed plates or films of any subject which contains the ordinary scale of bright lights and dark shadows or bright and dull colors or both, the time of the first visible appearance of the image bears a fixed relation or is a constant fraction of the time required to secure absolutely perfect development.

The factor or co-efficient of all known developers vary from 4 to 34. My extensive experiments have proven to me that in order to ascertain the time of perfect deevlopment of exposed sensitized mediums in any given developer, the time of first visible appearance must be ascertained to a marked degree of precision and certainty. That is, it should be registered in seconds and not in greater time units, which would only approximate the time of first appearance. For instance, my experiments have often proven, that 17 seconds for example, the first appearance was distinctly visible, in 18 seconds it was more distinctly visible while in 16 seconds it was not visible at all. Consequently, it is obvious that for precision in perfect development, the time of the first appearance should be recorded in the shortest unit of time which will mark a perceptible difference.

Consequently a co-efficient of activity may be determined for any developer by ascertaining the exact time required for correct development under a given set of conditions, then finding the exact time to produce the faintest visible image or appearance in the same developer and under the same conditions, and taking the ratio of these values; in other words, dividing the time of complete and perfect development by the time of the first visible appearance. This co-efficient will hold good for the given developer or any developer made of exactly the same constituents and proportions at all times and under all conditions. Thus, if the time of perfect development be five minutes and the time of the first visible appearance be one minute, the coefficient of activity of the developer is 5. The actual activity or energy of the developer may be increased 100% by a rise in temperature alone. The first visible appearance would then occur in thirty seconds. If this value be multiplied by the coefficient 5, the result would be two and one-half minutes, which would be the correct time for perfect development under the changed condition. If by constant use or a lowered temperature the energy of the same developer was reduced until the first appearance became visible in three minutes, then multiplying this quantity again by the coefficient, a result of fifteen minutes is obtained, which is the absolutely correct time for perfect development in that solution under those conditions. Consequently having once ascertained the coefficient of a developing solution, I propose at any time thereafter when films or plates are to be developed to determine the time of perfect development under the then existing conditions by ascertaining the time of first appearance of image at that time and multiplying this by the previously ascertained coefficient.

In order that the result when obtained shall be accurate, however, it becomes exceedingly important to provide method and means for ascertaining the time of first visible appearance quickly, readily and accurately. As heretofore explained, the ordinary dark room process does not afford such facilities. Say that a developer has a co-efficient of 30, a mistake of only five seconds in our calculation of the time of first appearance, when a development is to be made would mean a mistake of two and one-half minutes short of or exceeding the time of correct and perfect development in such case. With a co-efficient of 5, an error of five seconds in the time of first appearance would result in an error of twenty-five seconds in the calculated time of correct and perfect development. In either case the imperfection in the result caused by the error would be serious.

While this process applies to all sensitized developing mediums such as positive and negative plates and films, bromid papers, etc., in order to avoid confusion and more elaborate and extensive explanation of the process and its requirements in the way of

apparatus, I will refer more especially to the development of motion picture films.

In the accompanying drawings:

Figure 1 is a semi-diagrammatic side sectional view of an apparatus for carrying out the invention;

Fig. 2 is a side elevation on a smaller scale of an alternative apparatus;

Fig. 3 is a plan view of Fig. 2;

Fig. 4 is a face view of a chart from which an indicator may be produced photographically;

Fig. 5 is a face view of such indicator after being progressively developed, the same being shown in its holding frame; and

Fig. 6 is a face view of another chart.

In order to ascertain the time of first visible appearance of the image with certainty and despatch, I provide myself with a strip of motion picture film or other suitable sensitized medium on which I secure a latent image of one of my charts to be used as the indicator. This can be done by a direct process of photography, that is, place the sensitized medium in the camera and secure the latent image by directly photographing the chart. Or it can be secured by printing from a previously made negative of the chart. However, in either case, the exposure should be correctly made. I now subject successive portions of this exposed medium to the action of the developer, for successively greater or less predetermined periods of time. The successive periods of time, predetermined to correspond relatively to the successive portions, divisions, or gradations of my indicator. When the last portion or division of my indicator has been subjected to the action of the developer, for the period of one second, the action of the developer is then immediately arrested by dashing the indicator or exposed sensitized medium in a solution of water acidified with sulfurous acid. Thereafter, this indicator can be examined by any source of white light, without suffering any perceptible change. It will be observed by the accompanying drawings herein given for the purpose of illustration that I provide means to support my sensitized indicator, in the developing cylinder of the apparatus in such a way that the top of section No. 1 of my indicator comes flush with the top of the developing cylinder or receptacle; consequently, when the developer rises to the point of overflow, this indicates without the use of a watch, the exact time to remove the indicator and arrest the development. We will assume for example that my indicator is fifteen inches long and divided into 120 equal parts, or in equal divisions of $\frac{1}{8}$ inch each. Each part or section preferably numbered, commencing with No. 1 at the top and each of the successive lower sections, successively numbered 2, 3, 4, etc., to 120, the bottom or last section. My apparatus is now adjusted so that the developer rises in the developing receptacle at the rate of $\frac{1}{8}$ inch per second. When the developer reaches the point of overflow at the top, the bottom section or No. 120 will have received exactly 120 seconds of development; while the top section or No. 1 will have received one second development. While the image will be very clear and distinct and possibly even dark at the bottom section of this indicator, the top section or No. 1 and other sections near the top, will remain blank for the want of sufficient development to create a visible image. But continuing farther down from the top, the first visible image will be a number, which will be faint but clearly readable and this number will represent in seconds, the exact time of development required to produce that faint visible image. Proceeding from this point downward, each successive section of my indicator, by reason of having received successively greater periods of development will be successively stronger and stronger all the way to the lower end, or the last section No. 120; and from the faintest image downward, each separate section automatically and in legible figures, representing seconds of time, gives the exact time period of development it has received. Consequently, by visual inspection to be made by good and sufficient light, either with or without a simple calculator, according to the design of the indicator, the time of first appearance can be arrived at immediately and with absolute certainty.

There are various ways in which such a strip or indicator may be progressively developed. I prefer, however, to place it upright in a suitable frame within an upright receptacle and to admit the developer to the receptacle at a predetermined rate, so that the developer rises up the strip. Thus, if the rate of supply be fixed so that the developer rises one division upon the indicator per second and if the progressive submersion be continued until the developer covers the top division, the indicator being then at once removed and placed in an acidulated bath to stop the development, it will follow that the said top division bearing the numeral 1 will have been in the developer one second, the next lower division marked 2 will have been in the developer two seconds, and so on down to the bottom. Consequently the time of first appearance may be ascertained by direct reading of the division or section or portion of the indicator where the image, numeral or otherwise, first appears. Thus, if the number of this section is 15 and the coefficient of the developer be 5, it is at once found that the time of perfect development under the then existing set of conditions will be

75 seconds or one minute and fifteen seconds. Proceeding a step farther, it will be apparent that, instead of numbering the indicator from 1 on, it may be numbered in terms of the coefficient, that is to say, the divisions may be marked—instead of 1, 2, 3, 4, etc.—5, 10, 15, etc. In this way, direct reading of the section showing the first image will give the time of perfect development without calculation, the multiplication having already been effected. Instead of causing the developer to move relatively to the indicator I may bring about the progressive submersion by lowering the indicator at a predetermined rate into a standing body of the developer. It will be understood that the relative movement between the indicator and the developing fluid may be either continuous or intermittent.

In making the indicator I first produce a chart A, by drawing or otherwise, such as shown in Fig. 4. For purposes of illustration this chart is shown as a strip bearing graduations and numerals from 1 to 40 in solid black upon a white ground. However, white upon a solid black ground is equally effective. Of course it will be understood that this chart may be of any size to best suit my requirements and to extend to sections or numbers greater than 40 and also be it understood that the chart may be a scale only and without numbers, which in such case can later be compared with a scale of numbers, having relatively or correspondingly the same scale of division; or, the chart may be of numbers only, having predetermined or known degrees of separation. The successive markings may be made like or similar to an ordinary ruler or yard stick, or as the measured markings of a thermometer, or any other markings or scale of measure divisions, lines, figures, letters, symbols, characters or designs which will provide the means of calculation for ascertaining to a degree of constant precision, the time required to secure the first visible appearance of image or indicate the time of perfect development.

For illustration, referring again to Fig. 4, by photography I obtained a perfect negative of this chart, enlarged or reduced or of the same size, depending upon the size of scale desired for my indicator. From this negative by proper exposure upon our motion picture film or other suitable sensitized medium, I secure a latent image of my chart; one of these prints constitutes the letter B, for convenience is retained in a suitable frame C, which holds it rigid. Now by progressively developing the indicator until, as in this illustration, section or division No. 40 has had its 40 seconds development, and each successive number or division above has had successively one second less development, until this top section or No. 1 is reached by the developer and receives as its number indicates, one second of development, thereupon instantly arresting the development, the result may be secured such as Fig. 5. Here all the upper part of the indicator from No. 1 to No. 26, inclusive, is completely under developed and blank. At the 27th division, is a faint or so called first visible appearance and within this section number twenty-seven appears as the image, faint but easily readable. From this division down, the images become successively darker and more intense. Therefore it is obvious that in the case of section No. 26, this number did not appear on the indicator for the lack of one second more development. Consequently in this particular instance, this particular developer and under the particular conditions obtaining, the time of first appearance of the image twenty-seven, was 27 seconds. If the coefficient of that developer be 5, the time of perfect development will consequently be 135 seconds or 2 minutes and 15 seconds.

Fig. 6 shows a chart A′ in which the numbers are already expressed in the terms of the coefficient. Consequently with an indicator made from such a chart the section showing the first appearance of the image will give, by direct reading, the time of perfect development. In other words, with such a chart the calculation has already been made. Manifestly many other suitable indicators may be designed.

Fig. 1 illustrates in a schematic manner a form of apparatus for effecting progressive development of the indicator. The said apparatus comprises an inverted bottle 2, containing developer, and representing the source of supply, said bottle being represented as supported upon an arm 3 adjustable upon a standard 4 rising from a suitable base 5. Beneath the source upon the base 5 is a feed reservoir 6 open to the atmosphere and provided with means for maintaining a constant level or head therein. Such means may comprise an outflow tube 7 and an air inlet tube 8 passing through the plug 9 in the mouth of the inverted bottle, the tube 7 projecting downward below the lower end of the tube 8. As will be readily understood this organization will not permit the water in the reservoir 6 to rise higher than the lower end of the air tube 8, while descent of the level below this point will permit entrance of air to the bottle and cause liquid therefrom to flow into the reservoir and thus bring the level back to the fixed point. The upright receptacle 10, in which the indicator in its frame C is placed, is seen suitably supported below the reservoir 6. It remains now to provide the reservoir 6 with an outlet which will cause the developer to enter the receptacle at the desired predetermined rate, that is to say at such rate that the developer

will rise upward upon the indicator one unit division per second of time. Such outlet may consist of a pipe 11 leading from the lower part of the reservoir and entering the top of the receptacle 10, this pipe containing a suitable exactly adjustable valve 12, which may be set to cause the developer to rise in the receptacle at the rates of, for example, one-eighth of an inch, one-quarter of an inch, three-eighths of an inch, or one-half an inch per second, depending upon the size of the divisions of the indicator. It will be understood that for indicators of different heights, receptacles of different heights may also be provided. The pipe 11 also bears a shut-off cock 13, and in order to prevent splashing in the receptacle 10, the conduit may be continued to the bottom by means of tubing 14.

Figs. 2 and 3 represent a form of apparatus wherein a receptacle 10^a contains a standing body of developer, while the indicator frame C′ is raised or lowered into or out of the body at a predetermined rate by means of clock work 15. For purposes of illustration the frame C′ is shown formed upon one edge with rack teeth 16, which are meshed by a pinion 17 of the said clockwork, while the opposite edge of the frame is guided in a grooved guide 18. In order to permit the frame and indicator to be instantly removed or inserted, the said guide is shown as hinged at 19 to a suitable support 20 and held by a spring 21 to its operative position. A handle 22 on the hinged guide enables it to be thrown quickly open, so that the frame can be raised or lowered clear of the pinion 17.

Reference may be made to the matter of toning. The toning of films adds a certain degree of intensity. Consequently when films are to be toned, it is desirable to stop the development correspondingly short of the time of perfect development. The amount of the intensity added by toning can be ascertained and due allowance made in the indicators and in the procedures heretofore described.

I have not heretofore described the method of arriving at the coefficient of activity of any given developer in the first instance. This is done only once and it is not particularly important whether the means and method employed are expeditious or not. However, it will be apparent that the invention provides a way of ascertaining the coefficient very easily. All that is necessary is to place a strip of properly exposed motion picture film, for example, in the apparatus of Fig. 1, again by way of example, and to set the valve 12 so as to admit the developer at the appropriate rate. This strip being of sufficient length will contain both the first visible appearance of the image and also sections which are more than correctly developed. Between the lower end of this strip and the faintest visible image above, will be found a section which has had correct and absolutely perfect development, and on either side of this will be found several other sections that approximate correct development.

However, near the approximation their imperfections will be clearly noticeable when compared with perfect results. Knowing the rate of rise of the developer, it is very easy to measure with a ruler or a specially devised measure, and ascertain both the time of first visible appearance and the time of perfect development, and thus the unknown factors or coefficients are attained.

Still another use of the apparatus of the invention in its various forms may be alluded to. This is the tinting or coloring of films. By ordinary methods it is difficult to secure or to reproduce just the exact shade of any color which may be desired for a particular film. In order to secure any desired tint or color in photographs, films, plates or paper, positives or negatives, I propose to provide a scale of perfectly graduated shades of each color, ranging from the faintest perceptible shade to the deepest color practically used. Such a scale can be made on films or plates and will serve as a standard scale or chart for future comparison. These scales can readily be produced by progressively submerging a strip of film itself, or the like, in the desired dye in any of the forms of the apparatus of the invention. Such color chart may be graduated and may bear numbers, or the time of immersion necessary for any shade at any point along the scale may be ascertained by placing the scale alongside a rule, graduated to correspond to the rate of submersion of the strip in the dye.

What I claim as new is:

1. Method of determining the time of perfect development in a given photographic developer under a particular set of conditions, which comprises initially ascertaining the time of perfect development and the time of first appearance of image with the developer under the existing conditions, taking the ratio of these values to obtain the coefficient of activity of the developer, thereafter when exposures are to be developed subjecting successive portions of a sensitized exposed indicator having small equal subdivisions to the action of the developer for known graduated periods of time, arresting the development, and from the time of first appearance of image on the indicator multiplied by the coefficient of activity ascertaining the time of perfect development under the new set of conditions.

2. Method of determining the time of perfect development in a given photographic developer under a particular set of conditions, which comprises subjecting successive

portions of a sensitized exposed indicator having small equal subdivisions to the action of the developer for known graduated periods of time, arresting the development, and multiplying the thus ascertained time of first appearance of the image by the coefficient of activity of the developer.

3. Method of determining the time of perfect development in a given photographic developer under a particular set of conditions, which comprises subjecting successive portions of a sensitized exposed indicator having small equal subdivisions to the action of the developer for known graduated periods of time, arresting the development, and from the time of first appearance of image multiplied by the coefficient of activity of the developer ascertaining the desired time of perfect development.

4. In a method of determining the time of perfect development in a given photographic developer under a particular set of conditions, the steps which comprise subjecting successive portions of a sensitized exposed indicator to the action of the developer for known graduated periods of time, and immediately arresting the development, in order to ascertain the time of first appearance of image.

5. In a photographic process, the steps which comprise immersing a sensitized exposed strip having small equal subdivisions in a developer at a predetermined rate, and immediately arresting the development, and thereby obtaining a graduated series of developments corresponding to known periods of time.

6. In a photographic process, the steps which comprise immersing in a developer a sensitized exposed indicator strip which is graduated as to time, so that the sections of the strip are acted upon by the developer for corresponding periods, and immediately arresting the development.

In witness whereof, I have hereunto set my hand this 4th day of March, 1918.

EUGENE B. DOWNING.

Witnesses:

GRACE H. EMPEY,

CLARENCE G. GALSTON.