John L. Davenport, Constant Quality Prints (Part 1),
U.S. Camera, 1940, vol. 3, no. 12, pages 55-57, 60-61.

CONSTANT QUALITY PRINTS

A method for obtaining technical excellence in prints by controlling negative contrasts

By John L. Davenport

EDITOR'S NOTE: *Mr. John L. Davenport has developed a method of combining, for direct application, the information heretofore contained separately in a Scene Brightness Range-Gamma table and in the characteristic curves of negative emulsions (or the derived Time-Temperature-Gamma curves). The method employs supplementary exposure meter dials, seven of which are printed with this article. The use of any one of these dials enables the photographer at the time of exposing to read the contrast to which the negative should be developed in order that a good quality print may be obtained on normal paper.*

The first half of Mr. Davenport's article appears in this issue and deals primarily with the application of the system. The second part, which will be published in U. S. Camera No. 13, is devoted to a discussion of the theory and construction of the supplementary dials. Both Mr. Davenport, a chemical engineer and an advanced amateur photographer, and U. S. Camera's editors believe that the careful application of the method given in this article will solve many of the print quality problems of photographers who are striving for technical excellence.

The Purpose of the Article

The ultimate aim of all photographers is to make consistently good photographs. There are two essential requirements for a good photograph; first, good subject matter, and second, good technical quality. We are concerned here only with technical quality.

It has been pointed out by many writers that if only a photographer could be sure of always obtaining technical quality, then he would be released for concentration on the serious business of selecting good subject matter.

The purpose of this series of articles is to explain a simple method of attaining technical excellence on the finished print. It requires a camera which has a reliable shutter and lens, a condenser type enlarger, and a Weston Universal or Master exposure meter.

Before going further, there should be some understanding of the meaning of technical "quality." All photographers know the appearance of a "soot and whitewash" print. They also know a "flat" print. Somewhere between these two extremes lies the "quality" print. Of course, no two people will always agree as to whether one print has more "quality" than another, because some are pleased by brilliance and others by softness. However, a careful examination of prints that have "quality" will reveal that they have the following points in common:

1. A mass or accenting lines that are rich black
2. A mass or accenting lines that are practically white
3. A number of intermediate half-tones that show pleasing tonal differences

From this it is plain that technical "quality" is closely bound up with contrasts, and if good quality is to be obtained, then the photographer must learn to control contrasts.

Let us consider a particular case.

A picture is to be taken of a girl in a light dress under a tree. If the picture is taken on a brilliant sunshiny day, there is a tremendous contrast between the light values of the dark tree trunk and the dress. If this negative is now developed to a gamma (or contrast) of 1, it will reproduce the contrast in tones seen in the original picture. However, when an attempt is made to print the negative on paper, it will be found that the girl's dress has no detail in it (a so called blocked highlight) and the tree is practically black (no detail in shadow). We have here then a "soot and whitewash print." An examination of the negative will show nice detail in the shadow and good contrast differences in the girl's dress. The reason for the above observations is that negative materials will depict a greater brightness range of light than papers. Most good negative materials faithfully show a brightness range in which the highest light value can be 130 times greater than the lowest light value, whereas the best glossy print will depict a brightness range in which the highest light value is only 40 times greater than the lowest light value.

The average photographer will solve the problem presented in such a negative by:

1. Throwing it in the scrap basket
2. Printing the full detail in the girl's dress and letting the tree get coal black, i.e. no detail in shadow
3. Using the softest paper he can buy and hope for the best

The experienced photographer would handle the matter quite differently. He would realize when he took the picture that it had too much contrast. To compensate for this, he would develop the film by inspection for less

Fig. 1. Ordinary exposure meter dial.

Fig. 3. Proper dial setting for the scene of average brightness range above.

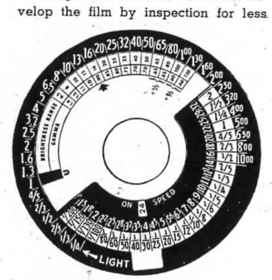
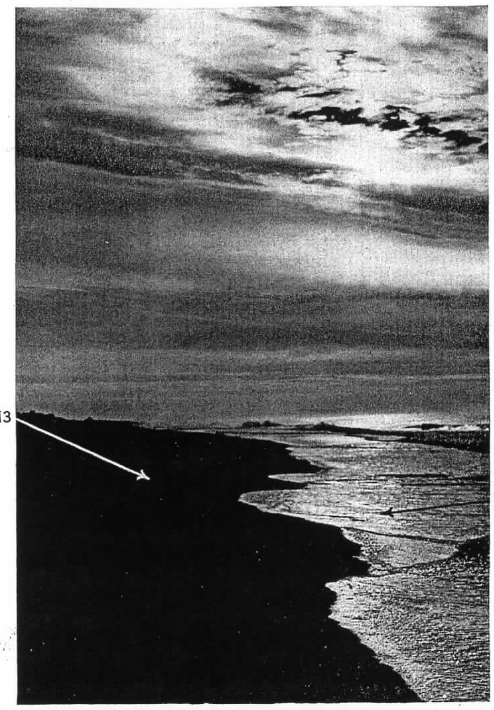


Fig. 2. Exposure meter dial with supplementary dial.

Fig. 4. (Left) A subject of very low brightness range; the lighting here is extremely flat.

Fig. 5. (Right) A scene having a great brightness range. Against-the-light photographs such as this usually have extremes in light values.



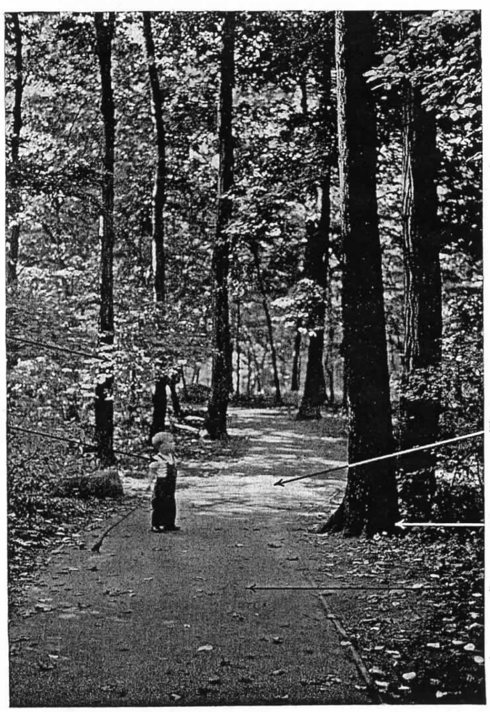
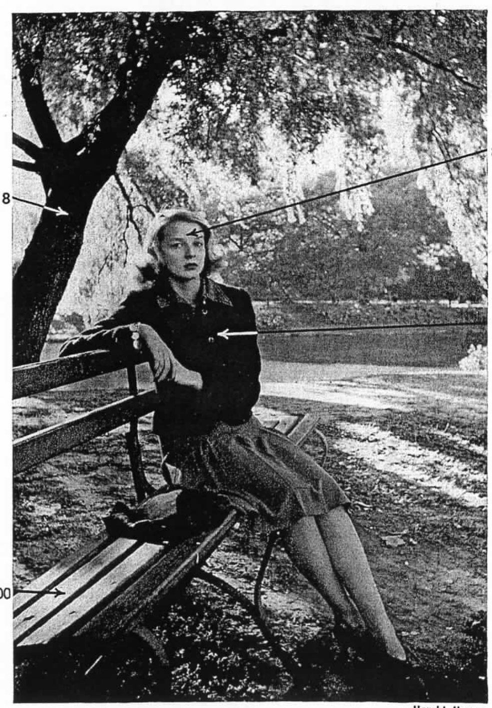


Fig. 6. (Left) A scene in which everything is flatly lighted except two small highlights. Here, discrimination has to be used, and the boy's sweater is taken as the brightest object.

Fig. 7. (Right) A scene of great brightness range. Here again discrimination has to be used in determining meter setting to produce the best picture.



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John L. Davenport, Constant Quality Prints (Part 1),
U.S. Camera, 1940, vol. 3, no. 12, pages 55-57, 60-61.

than normal time, and thus reduce the contrast to the point where it could be printed on a normal paper. Up to now however, this has been a matter of guesswork and it took long experience to determine how much the developing time should be reduced. Further on in this article it will be shown how even a beginner can tell precisely how long the above negative should be developed, in order to fit it to the scale of a normal paper.

Suppose now that the picture of the girl in the light dress under the tree is taken on a dull cloudy day. The contrast between the dress and the tree is reduced sharply. If the negative is developed to a gamma of 1, the original contrasts of the subject will be shown on the negative. However, when it is exposed on normal paper, the print is flat. The average photographer would either reject the result, or try to print the negative on contrast paper. The experienced photographer however, would develop the negative for longer than the normal time and raise the contrast of the negative to the point where it would give a good print on normal paper. There are limits to how far this can be carried but it will be shown just what those limits are.

The particular facts in the above examples can be summarized briefly as follows. Contrast in a negative is the result of two things: (1) the contrast of the subject taken and (2) the contrast to which the negative is developed. There is much literature and data (see *Photo-Lab-Index*, Morgan and Lester, New York) on how different negative materials can be held to definite contrast or gamma. Hence the need now is to determine the contrast of the subject matter and tie it to development contrast so that a constant quality negative is produced which auomatically fits the scale of a normal paper. It is the purpose of these two articles to show that a simple relationship exists that anyone can apply to his photography.

In what follows there is nothing that cannot be understood by anyone who has had a few years of high school.

There is always a tendency among photographers to shun the application of mathematics to their hobby. If the reader is frightened by the mention of a logarithm, it is suggested that he devote his attention to the easy rule of thumb method described herein. Later on when he becomes curious as to why the thing works, he can then spend a profitable evening reading over the second part of this article which will appear in the next issue. Sensitometry is the fundamental essence of photography and an understanding of its principles will improve anyone's photographic efforts.

The Method of Producing Constant Quality Negatives

This new method of contrast control involves the use of a modified form of the top dial of the Weston exposure meter. Fig. 1 shows the usual type of stationary and movable dial. Fig. 2 shows the new form of the top dial.

The pictures in Figs 3, 4, 5, 6, and 7 will show how the new dial is operated.

Due to the unavoidably shorter range of tones obtained in magazine reproduction, it may not be possible to discern detail in the shadow and certain tonal differences mentioned in the text.

Fig. 3 is the print of a scene of average brightness range. The negative was exposed by first setting the correct emulsion speed in the window at Weston 24. The lowest light value on the ship side was found to be 20. The U arrow of the top dial was set at 20 on the stationary dial. The brightest part in the scene was the painted trim on the hull of the ship. The meter read 400 on this spot. An exposure of 1/500 second at F/4.5 was chosen. Opposite 400 will be found the brightness range figure of 20 on the top dial. Directly underneath this is the figure 0.85. This means that the negative should be developed to gamma 0.85. The development time and temperature to get gamma 0.85 can be found in *Photo-Lab-Index* or in pamphlets issued by the various film companies. The negative was developed to gamma 0.85 and the negative densities were such that the best print was obtained on normal paper.

Fig. 4 is the print of a subject of very low brightness range. The type of lighting was that recommended by Mortensen for portraiture. This consists of one light shining directly at the subject from the camera lens and a second light on the background. It will be seen that this is almost the ultimate in flat lighting. Emulsion speed was 16. The subject's hair, the darkest part from which a reading could be obtained, was 3.2 candles per sq. ft. However, several accenting lines like the eyebrows, eyelashes, chin line, and insignia on the dress were darker, but could not be read directly. This was taken care of by taking a reading on a very dark cloth which matched the insignia. The reading of the dark cloth was 2.5 candles per sq. ft. The U marker therefore, was set at 2.5, and an exposure of 1/10 second at F/9 was chosen. The background, the lightest object, gave a reading of 16 candles per sq. ft.

Directly opposite the reading of 16, the brightness range of 6.5 was indicated on the top dial, and underneath this value, the gamma 1.4, to which the negative was developed. The best print was obtained on normal paper.

Fig. 5 is the print of a scene of great brightness range. Against-the-light photographs usually have extremes in light values. Emulsion speed was Weston 24.

The darkest portion of the sand gave a reading of 13 candles per sq. ft. The lightest portion of course, was the glittering sun on the water. This gave a reading of 1000. Under 1000, a brightness range of 80 was indicated, and a gamma of 0.65 to which the negative was developed. A high brightness range requires more exposure. In this case 1/3 stop extra exposure was made by rotating the top dial one division to the left. An exposure of 1/200 second at F/5 was chosen. (See further explanation of stops on page 60). The best print was obtained on normal paper.

From these three examples the general rule is now apparent:

1. Set the meter at the correct emulsion speed.
2. Set the U arrow at the lowest light value and keep this setting to determine the F stop and shutter speed.
3. Measure the value of the lightest portion of the subject.
4. Read off the *brightness range* of the subject and the *gamma* to which the negative should be developed. The negative can now be printed on normal paper for best results.

These four simple rules will enable anyone who is seriously interested in consistently good technical quality to put his contrast control on a par with the best work being done today. As stated earlier, this method of control has been guesswork up to now except in the movie industry. It has always been necessary for the photographer to get the "feel" of his medium by the long experience of trial and error. This is why the good photographers have always urged the tyro to stick to one film and one developer.

The new top dial has been worked out from actual sensitometric data, and is accurate for all practical purposes. In order to make it most effective, it was found necessary to use definite films with definite developers. This was necessary because film characteristics vary a great deal. Sometimes there are combinations which are identical. On this page will be found several dials with definite film and developer combinations. These are the correct size for the meter, and may be cut out and pasted over the present top dial. The method used in constructing the new dial will be described in the next issue.

The Use of Judgment in Determining Brightness Range and Gamma

On certain occasions it may be necessary to use discrimination in predetermining just what the brightness range should be, to make the best picture. For instance, suppose a scene is to be taken in which everything is lighted flatly, except one small highlight or one small portion of dense shadow. Fig. 6 is an illustrative example. Here the darkest shadow is 1, and the small highlight in the path is 50. Following the four rules given above, a brightness range of 50 and a gamma of 0.70 would be chosen. Obviously, a flat photograph would result, because most objects in the scene are flatly lighted. To correct for this, the little boy's sweater was selected as the brightest object, giving a brightness range of 10 and a gamma of 1.1.

Let us suppose that the little boy were moved into the bright patch of sunlight. In this case the center of interest would be brightly lighted beside a dark tree trunk, and the photographer would be obliged to use a brightness range of 50 instead of 10.

The generalization here is that the subject and its immediate surroundings are the most important part of the picture, and as such should have good contrasts in order to make them stand out.

Fig. 7 is another example of this generalization. The emulsion speed was 50. The dark part of the tree trunk gave a reading of 8.0 The greatest highlight was the sun behind the tree which gave a reading off the meter scale. It was decided that this would be white on the final print anyway, so it was disregarded, and the highlight on the bench, which read 500, *(Continued on page 60)*

SUPPLEMENTARY DIALS

No dials have been made up for the very high speed films. The reason for this is that their characteristics tend to be erratic, their speeds often vary, the grain is large, and they are not as reliable as the slower speed, quality emulsions.

Manufacturers' instructions for obtaining definite gammas should be followed as closely as possible. There is, however, some margin for error, because normal paper has some flexibility in the range of negative densities that it can handle.

It will be noted that in some of the dials the gammas start at 1.0. The reason for this is that the film-developer combination cannot produce any higher gammas no matter how long the development.

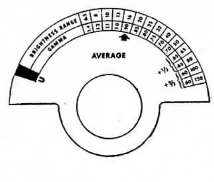
An average dial has been included in the group. This can be used to good advantage on most films, but it will not be entirely accurate, due to variations in film and developer characteristics. In using this dial, make sure that gammas of more than 1 are obtainable before taking pictures of a brightness range lower than 13.

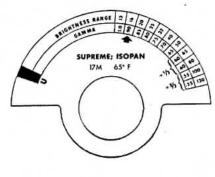
If DK-20 developer is used in the case of Plus X or Panatomic X, add .05 gamma to all gamma figures listed on the D-76 dial. This will be close enough for all practical purposes.

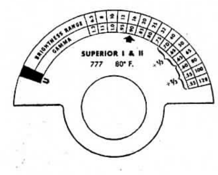
The brightness range figures on the top dial are not absolutely essential to the operation of the method. They are placed there for the purpose of having the photographer always think of his subjects in terms of brightness range. It is one of the most important conceptions in photography and has been neglected too long.

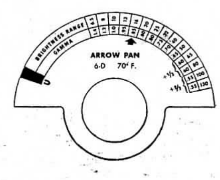
Isopan with Agfa 17M will not reach a gamma of 1.0, so do not use a brightness range less than 16.

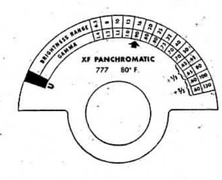
Before pasting dial on meter, cut out center circle.

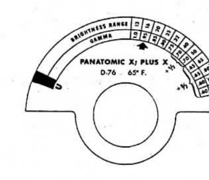


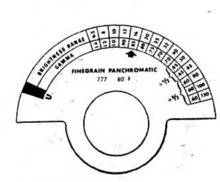












John L. Davenport, Constant Quality Prints (Part 1),
U.S. Camera, 1940, vol. 3, no. 12, pages 55-57, 60-61.

CONSTANT QUALITY PRINTS

(Continued from page 57)

was selected for use. The brightness range was 65. Due to the length of this range, the dial was set back 1/3 of a stop (see below), so that the U was opposite 6.5. An exposure of 1/40 second at F/12.7 was selected. The film was developed to gamma 0.65 and printed on normal paper.

Increasing Exposures for Long Brightness Range Subjects

A third series of figures will be noted on the new top dial from brightness ranges 65 to 130 (see Fig. 2). The notations +1/3 and +2/3 mean that extra exposure of 1/3 or 2/3 of a stop should be given to all subjects which have a brightness range of 65 or over. The Weston meter has been constructed so that each division on the dial is equivalent to 1/3 of a stop. Hence if the U on the top dial is rotated to the left one division, the meter is automatically adjusted to give 1/3 of a stop additional exposure.

Any Type of Quality

There may be some who will not like the quality of pictures obtained using the special dial method. They may prefer softer photographs or they may prefer more contrast. This may be accomplished by simply subtracting a point or adding a point to the gamma figures listed on the dial. In other words, a softer photograph will be obtained if the dial gamma figure of 0.8 is reduced to 0.7. A photograph of greater contrast will be obtained if the dial gamma figure of 0.8 is increased to 0.9. This affords a method of obtaining any desired quality. The student may make his own dial by careful study of the material which will appear in the second part of this article.

The above adjustment for quality may also be used by those who use non-condenser type enlargers, which generally give softer images.

How to Determine Film Speeds

Due to variations in films, shutters, lenses, and developers, it sometimes happens that films do not have the same speed that is listed. The following method affords a good check up. Pick some uniformly lighted object that contains intricate detail. A tree trunk is a very good object for this purpose. Suppose that the film is rated at Weston 24, and suppose that the tree trunk gives a uniform reading of 8.0 candles per sq. ft. Set the U arrow at 8 and the emulsion speed at 24. Now make an exposure of 1/100 second and at F/6.3 or any other indicated figure. Change the emulsion speed to Weston 20 and make another exposure at the same shutter speed but change the diaphragm opening. A good choice in this case would be 1/100 second at F/5.6. Now change the emulsion speed to Weston 32 and again expose at the same shutter speed—a good choice here being 1/100 second at F/7.

When the film is developed, notice which exposure gave just printable detail in the tree trunk. The emulsion speed fulfilling this condition is the one that should be used, *regardless* of what speed may be listed.

Limitations

By this time the reader has asked himself how he is to handle a roll of film on which he has exposed negatives with varying brightness ranges. What may be the correct gamma for one negative will be wrong for another. The answer is that the film cannot be handled, and he may expect as many misses as he has always had, or he may hunt around for a paper that will take the abnormal negatives he has made. The only solution for the miniature camera is to buy bulk film and make a number of short film lengths. Then expose all pictures of approximately the same brightness range on the roll and mark it for correct development gamma. Another advantage for short rolls is that present miniature developing tanks are poorly designed for uniform development. The center of the roll gets much less agitation than the outside of the roll. A doughnut-shaped tank is needed, with not more than 2 or 3 turns of film. In developing the short lengths, be sure to keep the film in the outer grooves of the tank reel. The film can be kept in place by wedging a short piece of a wooden match between the film end and the groove.

Another disadvantage in the case of the miniature camera is that it is dangerous to go over gamma figures of 1.0 because of the rapid increase in grain size. The only method of

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U.S. Camera, 1940, vol. 3, no. 12, pages 55-57, 60-61.

solving this is to use very fine grained films like Panatomic X, Superior I, or Finopan. These can be developed to a gamma of 1.2 if the enlargements are not too great.

It is not possible to measure the brightness range of distant scenes. The substitution method (see Weston Instruction Booklet) will not work, because the shadows are not as deep when viewed from a great distance. The scene is flatly lighted. In a case of this kind use one-half normal exposure and develop to higher gammas than normal, say 1.0 to 1.1.

Filters may change contrasts considerably, and this is particularly so in the case of highly colored subject matter. Close observation of the behavior of a filter will soon disclose if allowance must be made for a reduction of development time due to increased contrast.

The method of course, is best adapted to cut film cameras where each negative holder can be marked for correct development.

Acknowledgment

This method of contrast control was made possible by the careful thought put into the construction of the Weston exposure meter. The writer is indebted to Mr. W. N. Goodwin Jr. who first showed* how the Weston meter could be used to predetermine negative densities. Also to Mr. H. P. Rockwell Jr. who showed** that there is a mathematical relationship between scene brightness range, negative development, and negative density ranges of printing papers.

* "Weston Emulsion Speed Ratings," by W. N. Goodwin Jr., *American Photography*, October, 1935.

** *Exposure Makes the Picture*, by H. P. Rockwell Jr., paper presented at Fourth Annual Convention at Rochester, October 14-16, 1938.

PHOTO-MURALS

(Continued from page 53)

than one inch on each edge of the strip). This one-inch overlap is necessary for several reasons: (a) the physical demands of getting a manageable cutting edge; (b) the inevitable accidents to the edge during processing; and (c) the unavoidable curl of the edge. Always give as much overlap as possible.

Small projection rooms may allow an easel holding only one strip of paper—that is, 40 or 50 inches wide. (The paper may actually be 41-42 or 51-52 inches wide.) In that case, the enlarging camera must be equipped with an *accurate* negative holder which can be adjusted on fine gearing, for both vertical and horizontal position. A part of the negative will be projected, then the negative moved so that the next section is in place, and so on. This implies extreme accuracy of construction, as in an enlargement of ten diameters, a deviation of 1/50 inch in the camera results in a deviation of 1/5 inch in the enlargement—more than enough to thoroughly ruin correct matching. Of course, if single enlargements only are to be made on paper of the maximum obtainable width, there is no necessity for elaborate adjustments on the camera. The height of the enlargement is, of course, important; if possible allow for an easel 10½ feet high. That would allow for a mural of about 6½ x 10 feet in two sections, or one of about 10 x 10 feet in three sections. If a large single projection wall can be had, it should be about 18 feet wide by 12 feet high. The larger the better, of course.

The wall or the easel should be *absolutely perpendicular*, and *absolutely at right angles to the axis of the lens of the enlarger.* In other words, it should be absolutely parallel to the plane of the negative, presuming that the axis of the lens is accurately at right angles thereto. This is of extreme importance, especially when matching is effected by the progressive adjustment of the negative. A slight deviation in the camera position and alignment cannot be tolerated.

Camera

A horizontal camera is imperative, for obvious reasons. It should be a sturdy machine, supported firmly on its base, which in turn, should be mounted on a four-wheel truck, using "mine" rails set in concrete as a stable track. The conventional portrait camera stand will serve very well, as it admits the raising and lowering of the camera to bring the axis of the lens to the center of the enlargement. A 10-foot high enlargement will mean that the lens should be 5 feet above the floor, or the base of the enlargement.

An 11 x 14 portrait camera can be re-made to function as an enlarging camera, but the conventional 8 x 10 enlarging camera will do very well. Except for certain special work, back and side swings are not needed. In fact, such refinements may only serve to weaken the structure of the camera and make it more difficult to align.

The bellows extension should be figured on the lenses to be used. It is good to have adequate bellows, as the camera may be used for ordinary enlarging and reducing as well as for murals. In the case of regular enlargements, a small easel suspended from overhead, or built up from the tracks, should be used. In this case, the easel may be moved; in the case of mural enlargements, the easel is stationary, and the camera is moved.

Lenses

When 8 x 10 negatives are employed, a lens of *at least* 12 inches focal length should be used. An 18 or 24 inch lens is better if the camera and the projection space allows. In other words, always use the longest focal length possible. One may find convenient focal-length and extension tables in any technical book. These will be of aid in determining the maximum focal length useable in one's equipment.

John L. Davenport, Constant Quality Prints (Part 2),
U.S. Camera, 1940, vol. 3, no. 13, pages 84-85, 95-96.

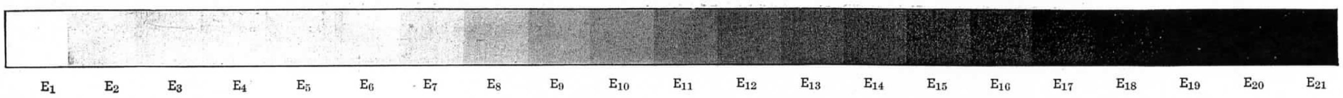

Fig. 8. A twenty-one-step sensitometric strip, the exposure has been doubled for every second step.

CONSTANT QUALITY PRINTS

The construction of supplementary exposure meter dials, based upon sensitometric data

By John L. Davenport

EDITOR'S NOTE: *The first half of "Constant Quality Prints" which appeared in U. S. Camera No. 12 described a simple practical method of obtaining technical print quality. It was specifically designed for those who know a picture when they see one, and who want to be certain that when they get home they will be able to produce a print of it that is technically excellent. This, the concluding part of the article is presented herewith and explains the theoretical aspect—why the method works. An example is given to show how the reader may make up his own dials. For those not familiar with photographic sensitometry, what follows may not be entirely light reading. The reader, however, is urged to spend a little time with it, because a grasp of the meaning of these photographic fundamentals will be of tremendous aid to anyone's photography.*

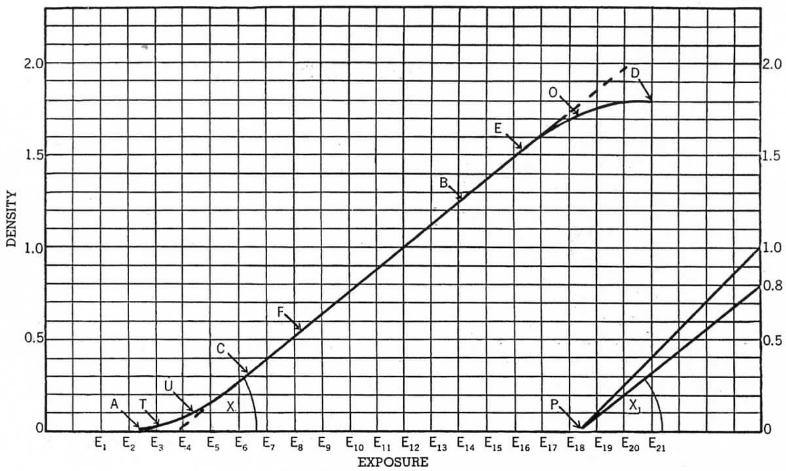

Fig. 9. The characteristic emulsion curve, plotted from densitometric measurements of the step wedge above. *A* to *U*—Region of underexposure; *U* to *O*—Region of correct exposure; *O* to *D*—Region of overexposure.

Sensitometry

Most photographers are aware that there is a branch of photography which has do do with film and developer characteristics, H and D curves, brightness ranges, negative density ranges, gammas and a number of other high-sounding terms that seem obscure. The truth of the matter is that they are neither obscure nor hard to understand. In what follows it is proposed to define all these terms and show how they are obtained.

Construction of H and D curve

The H and D curve is often called the characteristic curve or the D-log E curve.

A negative strip is exposed in an instrument called a sensitometer which has the ability of always reproducing the same exposures in meter-candle-seconds. The strip is exposed along its length in small squares. Every second square doubles the exposure. The resulting film is developed and when finished looks like Fig. 8 (the steps at the extreme ends of the scale reproduced on this page merge because of the limitations of the halftone process). The light stopping value of each square is determined by a densitometer and the value obtained is called density.

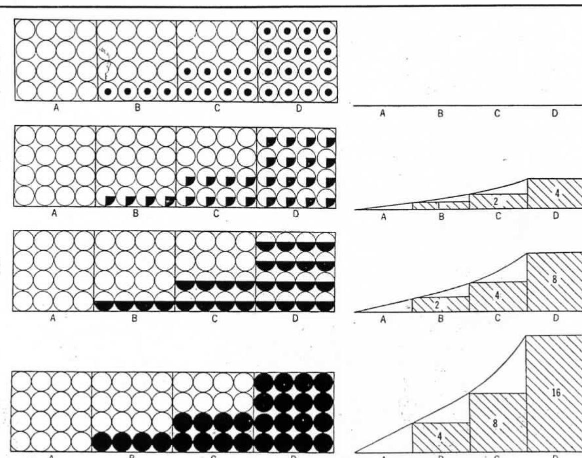

Fig. 11. Exposed but not developed.

Fig. 12. One-quarter developed.

Fig. 13. One-half developed.

Fig. 14. Fully developed.

The diagrams at the left represent four tones in an emulsion cross section at different stages during development. The curves at the right indicate the corresponding contrasts. They show that contrast is independent of exposure and increases with development.

The density of each square is plotted against its corresponding exposure as in Fig. 9. The exposure is always put in terms of the logarithm of the exposure. It will be observed that there are three portions to the curve. First, a curved section from *A* to *U* where relatively large changes take place in exposure without much increase in density, second, a straight section from *U* to *O* in which each change in exposure is proportional to the corresponding density, and third, another curved section from *O* to *D* in which large changes take place in exposure without much increase in density. In other words, twice the exposure in the section *U* to *O* will give far greater tone differences than twice the exposure in the section *O* to *D*. *A* to *U* is the region of underexposure, *U* to *O* the region of correct exposure, and *O* to *D* the region of overexposure.

Threshold Value — The exposure value which produces a just noticeable density on the developed film. It is marked at point *T* in Fig. 9. The Scheiner system of speed ratings is based on this value.

Inertia Point—When the straight line portion of the curve is extended to intersect the line of zero density, a point is obtained which Hurter and Driffield, the original investigators of this curve, called the inertia point (E_i in Fig. 9). The H and D speeds were determined by use of the formula $\frac{10}{E_i}$ where E_i was the exposure at the inertia point (E_i) in meter-candle-seconds. One meter-candle-second exposure is defined as one international candle at one meter distance for a duration of one second.

Gamma — If three sensitometer strips are developed for different lengths of time in the same developer, it will be observed that their contrast is different. The one that is developed longest has the greatest contrast. When they are plotted as described before they will look like Fig. 10. Note that the strip which was developed longest and has the greatest contrast, also has the steepest slope to the horizontal base. The

John L. Davenport, Constant Quality Prints (Part 2),
U.S. Camera, 1940, vol. 3, no. 13, pages 84-85, 95-96.

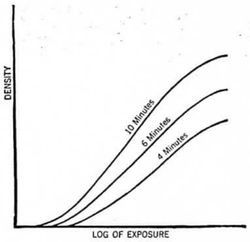

Fig. 10. Curves showing increase of gamma (contrast) with development.

steepness of the slope is measured by the angle formed between the straight line portion of the curve and the horizontal base. The tangent of this angle is called gamma, and is a measure of the contrast due to film development. It can also be measured graphically by drawing a line parallel to the straight line portion of the curve through the point *P* in Fig. 9. The point *P* is determined by drawing a forty-five-degree line through the point Density = 1 until it cuts the base line. The gamma can then be read off directly by noting the point at which the parallel line intersects the density line—in this case at 0.80.

The idea that the steeper the slope of the curve, the higher the contrast, or gamma, is an imporant one, and the following illustration is used to show just why this is so. It was used back in 1910 by Alfred Watkins to show the same thing. It is repeated here because it gives a good mental picture (although not wholly accurate because surface layers develop faster) of what happens in the emulsion during exposure and development.

Assume that the emulsion on the film has a considerable thickness as in the left half of Fig. 11. Assume also that *A*, *B*, *C*, and *D* represent four tones.

Each circle represents a bundle of light sensitive silver halide crystals. *A* receives no exposure, *B* receives exposure on the bundles marked with a dot in the center. *C* receives twice the exposure of *B* and hence has two rows marked with dots. *D* receives twice as much exposure as *C* and hence all bundles have been affected by light.

When the emulsion in Fig. 11 is immersed in the developer, the particles that have been affected by light are gradually converted to silver. Let us consider a time when the job of converting these to silver is one-quarter done. Then one-quarter of the affected particles are blackened and this can be represented in cross section as in the left half of Fig. 12.

Consider another time when the job is one-half done. This can be represented by the left half of Fig. 13.

When the job of development is wholly completed, it can be represented by the left half of Fig. 14.

The fixing solution dissolves away the particles that were unaffected by light, leaving only the blackened par-

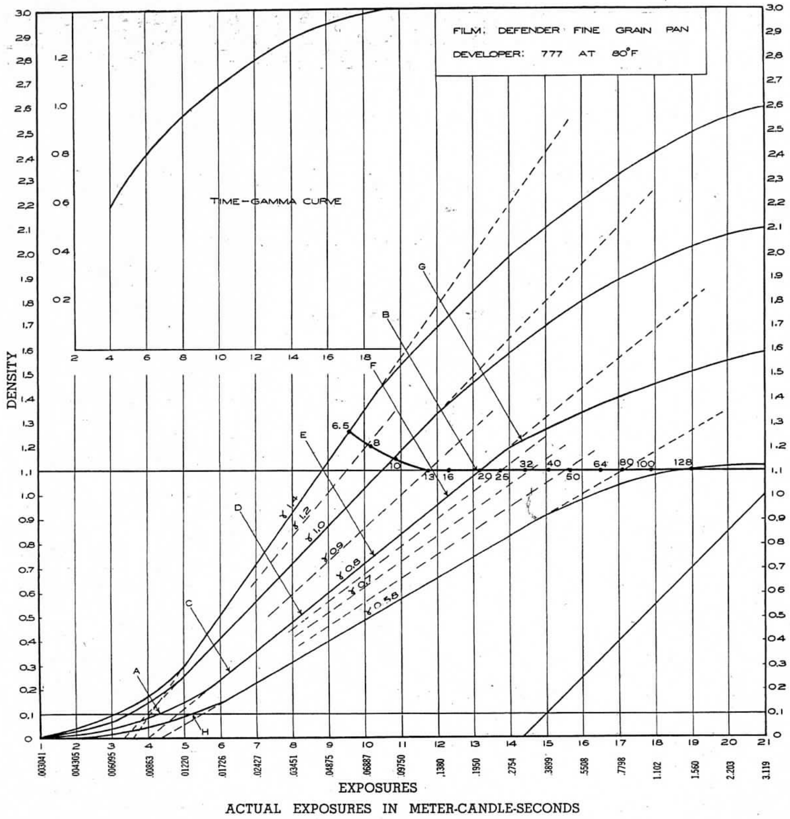

Fig. 15. A family of H and D curves from which supplementary dial values are derived. The Time-Gamma curve (upper left) indicates the number of minutes (bottom line) of development necessary to produce a required gamma.

ticles. Let us now calculate the amount of blackening that has taken place in Figs. 12, 13 and 14. Fig. 12, *A* will have zero. *B* will have 4 bundles × ¼ = 1. *C* will have 8 bundles × ¼ = 2. *D* will have 16 bundles × ¼ = 4. Let us put this down graphically in steps as in the right half of Fig. 12.

Fig. 13 *A* will have zero. *B* will have 4 bundles × ½ = 2. *C* will have 8 bundles × ½ = 4. *D* will have 16 bundles × ½ = 8. Graphically it would be represented as in the right half of this figure; and so in

Fig. 16. The first step in the construction of a supplementary dial.

Fig. 14, the values increase similarly.

It can now be plainly seen that as the development proceeds the contrast advances in proportion. If the steps are connected by a curve, it will be observed that the longer the development, the greater the contrast and the steeper the curve connecting the steps.

Brightness Range

Brightness range is the measure of the difference between the brightest tone of a subject and the darkest tone. Suppose the darkest tone of the subject measures 8 candles per sq. ft. and the brightest tone is 64 candles per sq. ft. Then the brightness range is 1 to 8 or 8.

Latitude of the Film

Every second square in the sensitometer strip doubles the exposure, therefore every second vertical line in the plotted curve, Fig. 9, also represents twice the exposure. From this it will be seen that the point O has 128 times as much exposure as *U*. Suppose a subject has a series of tones in which the brightest part is 32 times the lowest. This subject could then be fitted on the curve from *U* to *B*, *C* to *E* or *F* to O. In other words, if the subject was taken at a definite shutter speed and diaphragm stop, so as to fit the curve from *U* to O, the exposure could be increased four times and still get everything on the negative. The *F* to O negative would be denser, but its tonal qualities just as good as the thinner negative from *U* to *B*. This is spoken of as latitude of the film.

Suppose, however, that the subject has a series of tones the highest of which is 128 times the lowest. Then there is no latitude for exposure,

Fig. 17. The completed supplementary dial on the meter, ready for use.

because the picture just fits on the straight line portion between *U* and O.

A film which has a short straight line portion is thus a film of small latitude, whereas one with a very long straight line portion has great latitude.

Miniature camera users should work as close as possible to the *U* portion of the curve. This keeps the negative thinner and the grain size less. A method for holding negatives down to the *U* portion of the curve is described on page 60, *U. S. Camera* No. 12, under the heading "How to Determine Film Speeds."

Negative Density Range

The negative density range is a measure of the difference between the lightest density on a negative and the heaviest density. For example, a subject fitted on the curve in Fig. 9 between *U* and *B*, would have a negative density range from 0.1 to 1.28 or the total range would be 1.28 — 0.1 = 1.18.

The Method of Constructing the Top Dial

It is assumed that the reader understands how the H and D curve is constructed. It now remains to be shown how it has been used to construct the new top dial described in the first half of this article, which appeared last issue.

A definite film with a definite developer is used to obtain a family of H and D curves with gammas varying from about 0.6 to 1.4. Of course some developers and some films will not produce gammas as high as 1.4. That is why it is necessary to be specific with any one dial set-up.

Fig. 15 is an example of such a set of curves. These were obtained by using Defender 777 developer on Defender Fine Grain panchromatic film. The exposures are marked off as 1, 2, 3, etc. The actual meter-candle-seconds used is placed under each exposure. Notice that every other exposure represents twice as much light. For example Exposure 6 = .01726 c.m.s. and Exposure 8 = .03451 c.m.s. In terms of the camera lens this is equivalent to one full stop. Hence the difference between each exposure or vertical lines is one-half a stop.

Before going further, there is another fact with which the reader should be acquainted. Every grade of printing paper is capable of handling a different range of negative densities. For instance, if the maximum density on a negative is 1.1 and the minimum density is 0.1, then the negative density range is 1.1 — 0.1 = 1.00. Negatives that have short density ranges of about .57 to .70 require contrast papers in order to get good whites and good blacks. Negatives that have long density ranges of about 1.10 to 1.30 require soft papers. Most normal papers are capable of handling a negative density range of 1.00. Our goal then is to produce

(Continued on page 95)

John L. Davenport, Constant Quality Prints (Part 2),
U.S. Camera, 1940, vol. 3, no. 13, pages 84-85, 95-96.

the unhappy lot of nearly all artists—a pious virtue, and they are not infrequently big with pretension to being the only serious interpreters of life and truth. These are balanced on the other end of the political seesaw by a school of "economic royalists" who have made of art a commercial opportunity. As Industrial Designers with large staffs and control boards and troops of indefatigable press agents, they have welded art and commerce so successfully that it is nearly impossible to tell them apart. Somewhere between the two is the artist; and he is as often as not a forgotten man. Not quite poor enough to be picturesque or heartrending, just well enough off to keep his collar and his drawings clean, he must nevertheless spend an exorbitant part of his life and energies in worrying about bills.

And now, to stop the clamor of the butcher, the baker, et al., to whom must we sell our graphic arts? For the most part, I suppose, it will be to publishers, industrialists, and advertising agents. The publisher is a pretty decent sort, on the whole, but if he is a book publisher he can generally be recognized as such by the fact of having very little money to spend on art. In my own experience, the most generous and appreciative customer for our wares has been the industrialist. What you do for him can often increase his profit very materially, and he is not slow to recognize that fact.

The advertising agent, speaking very generally and with the particular exception of one very dear friend in mind, deals largely in what might be called scientifically organized fraud. I am aware that to say this now is to risk being called a "communist transmission belt"—whatever that may be. It has even been suggested that by these animadversions upon advertising, I am biting the hand that fed me; but I suggest that I am biting the hand that I have fed until I am fed up on feeding it. It may be that you will find, as I sometimes have, in the ranks of these shock troops of deception, sympathetic and amiable clients for your work who can deal differently with artists than they deal with the public—but not very often. Each of them employs what is called an Art Director, whose importance is derived not so much from art as from the financial size and number of advertising accounts towards which he directs it. It is his duty to furnish you with what he calls "ideas," upon the theory that an artist is not mentally up to having any of his own. Ten to one, he will end by altering your drawing to give it the "wallop" thought to be essential to all advertising. A public already groggy and half blind from the incessant battering of advertisements with a punch will hardly notice the difference.

"To think at all," says the Spanish philosopher, Ortega y Gasset, "is to exaggerate." A careful measurement of anatomical detail in the drawings and sculptures of Michelangelo will reveal startling exaggerations of fact, but these enlargements upon fact are but his medium for truthful expression. He gives us the figure of a man or woman more essentially true than could be made by any anatomist with micrometer calipers. So, I humbly pray, ladies and gentlemen, that you will apply no instruments of precision to my words—they are the best I could find in this emergency for saying what I believe to be true. If you think me guilty of exaggeration, the foregoing remarks are my only defense. But if you accuse me of being facetious, I will tell you that I have never been more serious in my life.

CONSTANT QUALITY PRINTS

(Continued from page 85)

always, negatives that have a density range of 1.00.

Now to come back to Fig 15. Assume that the Gamma 0.8 curve is the normal one for speed. It has been shown above that the *U* value on the meter should be at a density of 0.1 or the point *A* in Fig. 15. It has been shown that a negative density range of 1.00 is required. If *U* is 0.1, then the maximum density should be 1.10. Mark this point off on the Gamma 0.8 curve (point *B*). It is now necessary to determine what brightness range this represents. Go back to the *U* mark at point *A*. Note that it lies one-third of the distance between Exposures 4 and 5. At one-third of the distance between Exposures 6 and 7, twice as much exposure has taken place, or a brightness which is twice the *U* value (point C). At one-third of the distance between Exposures 8 and 9, four times as much exposure has taken place, or a brightness of four times *U* (point *D*). The points *E*, *F*, and *G* at brightness of 8, 16, and 32 times *U* respectively, are also shown. Note that point *B* is approximately one-third of the distance between brightness ranges 16 and 32. Hence point *B* indicates a brightness of twenty times *U*. Therefore with this developer-film combination, all pictures of brightness range 20 should be developed to gamma 0.8 to give a negative density range of 1.00. This is the first point to be marked on the dial. It has been shown elsewhere that every third mark on the meter doubles the brightness. By setting the *U* on the meter at 1, this first point is marked on the top dial as in Fig. 16.

In the same way all other points are obtained. There are however, two other matters to be taken care of. The reader will note that the exposure which produced a density of 0.1 at *A* on the Gamma 0.8 curve, produces a density of 0.22 on the Gamma 1.4 curve. The *U* mark is then chosen as 0.22 on this curve, with the maximum density at 1.22. A brightness of 6.5 times *U* is closest to this point.

It will also be noted that the

John L. Davenport, Constant Quality Prints (Part 2),
U.S. Camera, 1940, vol. 3, no. 13, pages 84-85, 95-96.

Gamma 0.58 curve has a density of 0.1 at an exposure one-half stop slower than the Gamma 0.8 curve. This means that all subjects having a brightness range beyond 80 require half a stop extra exposure in order to keep the *U* values at 0.1. As the meter is marked off in divisions of ⅓ stop, use ⅔ stop extra exposure instead of ½. In counting off the brightness range of the 0.58 curve, start at point *H* instead of at *A*.

The reader will observe on the Gamma 0.58 curve, that light values 80, 100, or 128 times *U* will all have approximately the same density, due to the flattening of the curve. If differentiation in tone is wanted in these higher values using this film and developer then detail in the shadow must be sacrificed and a higher light value of *U* used. The photographer is now up against the limitation of the printing paper. But having the dial at his disposal he is in a position to decide what he wants.

Taking the above details into consideration the remaining points on the dial can now be quickly plotted. It will be noted that the intermediate gamma curves have been drawn in lightly by interpolation in order to determine the points that fit the meter. These points have been marked on Fig. 15. A brightness range 6.5 is plotted on the Gamma 1.40 curve, 8 on Gamma 1.2 curve, 10 on Gamma 1.00 curve, etc. With the exception of the first three values, the points form a straight line that might be called "the constant quality line".

Having waded through all this, perhaps the reader will protest that he doesn't want constant quality because it would interfere with his artistic expression. The answer to this is that if he will once master constant quality and learn how to use his photographic tools, then he can vary his quality deliberately and know what he is doing, instead of hoping, as at present.

For detailed descripiton of sensitometry the following sources are recommended.

Photographic Sensitometry, Lloyd A. Jones, Journ. Soc. Mot. Pict. Eng., Vol. 7—No. 4 and 5; Vol. 8—No. 1 and 3.

Photography—Principles and Practice, C. B. Neblette, D. Van Nostrand Co., Inc.

The Handbook of Photography, Keith Henney and Beverly Dudley, McGraw-Hill.

Photography: Theory and Practice, L. P. Clerc, Pitman.

Exposure Makes the Picture and *Exposure Makes the Print,* H. P. Rockwell, Jr., Weston Electrical Instrument Corp.

Photo-Lab-Index, Henry M. Lester, Morgan and Lester.