PRACTICAL PHOTOGRAPHY

THE SECRET OF EXPOSURE

PRICE 50¢

AMERICAN PHOTOGRAPHIC PUBLISHING COMPANY · BOSTON, MASS

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THE SECRET OF EXPOSURE

Practical Photography, No. 1

EDITED BY

FRANK R. FRAPRIE, S. M., F. R. P. S.

Editor of AMERICAN PHOTOGRAPHY *and* POPULAR PHOTOGRAPHY

ELEVENTH THOUSAND

REVISED AND ENLARGED

American Photographic Publishing Co.

Boston, Mass.

1915

Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

THE
SECRET OF EXPOSURE.

Introductory. — The first roll of films teaches the beginner with the camera that there is an exposure problem to be met and mastered. If he be sufficiently interested to go over the negatives at the supply shop with the clerk, the latter points out to him that this one is not good because it did not receive enough exposure; that one, because it had too much; while the other is properly timed and gives a satisfactory print. Often, however, the results seem so good to the novice that he is delighted and goes ahead with the work without stopping to learn how to regulate exposure, and it is later, when bad results come thick and fast, that the awakening comes. At this stage, unfortunately, for want of proper help, many amateurs shelve the camera in disgust. Others — those whom we are addressing — refuse to be vanquished and ask to be shown how to master the all-important secret of exposure.

Vacation Snapshots. — So long as the camera is used only for the ordinary kinds of snapshots turned out by millions during the summer months, failures are not likely to occur. The manufacturers of even the lowest-priced cameras have provided lenses well fitted to give good results in intense summer sunshine with the snap of about 1–25 second which the shutter will make. This exposure, 1–25 second with stop *f*:16, is not enough, however, before 9 A.M. or after 3 P.M. One of the most usual failures which beginners make is due to their attempting snapshots very late in the afternoon, when the light is still bright to the eye but not capable of affecting the film sufficiently. The only remedy in such circumstances is to calculate the exposure by means of tables or a meter and use a smaller stop or opening in the lens with a short " time " exposure. This, of course, necessitates a tripod or other firm support to prevent the camera from moving and thus blurring the picture while the lens is open.

Limits of the Cheap Cameras. — Assuming that the beginner is equipped with a " fixed-focus " camera fitted with meniscus achromatic lens working at *f*:16 and a shutter giving 1–25 second and time exposures, exposures within the range of the combination will be found to lie pretty sharply within the hours named above. Snapshots in the shade, unless there is a flood of reflected light, will fail. So will those made too far from noon, on a dull day without sunlight, of objects very close to the lens, as bust portraits (except in direct sunlight), and in narrow city streets. Similarly, failure will follow the making of snapshots on the water; but in this case from overexposure. Sky and sea are so very brilliant that they affect the film too much. The use of a smaller opening or stop in the lens with the same speed of snapshot is the way to overcome this fault, as the smaller hole admits less light during the same duration of exposure.

Increased Latitude of Better Cameras. — From what has just been said, it is easy to deduce the fact that regulation of exposure is made more easy and certain if we have the power to change both the lens opening and the shutter speed. Hence if a camera is fitted with a double or rapid rectilinear lens, we have a greatly augmented range. Instead of a largest stop of *f*:16, we have one of *f*:8, which admits four times as much light. We have, generally, several speeds of snapshot, such as 1–100, 1–50, and 1–25 second. By paying more, we can get speeds running from time and bulb to automatically-regulated slow exposures of 1, 1–2, and 1–5 second (all too slow to use unless the camera is placed on a tripod) and snapshots as fast as an actual 1–250 or 1–300 second. It is, notwithstanding, hardly worth while to pay the top price for a shutter provided with so many speeds unless one also secures in it a fast anastigmat lens, which will open wider than *f*:8. One working at *f*:6 to *f*:6.8 will be found most suitable for general amateur work. The combination of a rapid lens with the many-speeded shutter will allow one to make snapshots early or late in the day, in the shade, or on dull days, and succeed admirably, if the correct exposure is known in advance and secured by regulation of the stop and the shutter speed.

Necessity of Information. — To expose correctly, then, it is requisite that the camera user study his instrument and the various factors which control the length of exposure and become thoroughly familiar with all the facts which can be brought to his aid.

The Problem. — All objects in nature reflect light to the eye. If the amount of light reflected is great,

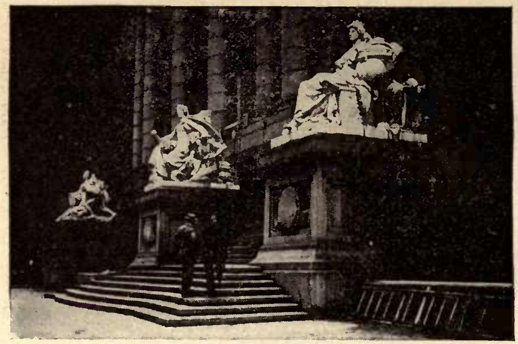


Fig. 1.—Underexposure. Also illustrating a Street Scene

as, for example, that thrown back by a sheet of white paper in sunlight, we call the paper a highlight. A piece of black velvet in shadow reflects very little light and is called a shadow. The tones between these extremes are called halftones. As a general thing, most photographs represent from four to six separate tones between pure white paper and the blackest shadows. For the sake of simplicity, let us take a wooden block painted white and set it in front of a black background and light it so that the white paint shall show to the eye three distinct tones—pure white and two intermediate grades of halftones. The black background forms the shadow, or fourth tone. Our task is to take a photograph which shall accurately represent these four tones as they look to the eye. The human organs of vision accommodate themselves almost at once to the light illuminating the object and the brain records a conception which does not change according to the length of time the block is viewed. In other words, it looks the same whether we gaze at it for a second or for a minute. With the photo-

Fig. 2.—Correct Exposure. Also Illustrating Average Landscape

graphic plate, on the contrary, it is far otherwise. The exposure, or length of time the light is allowed to act, must fall within very narrow limits or the result will be untrue to our visual impression. To understand this fully, let us briefly review the action of light on the plate or film.

Action of Light on the Plate.—The emulsion of the plate consists of innumerable small particles of silver bromide imbedded in gelatine. Each of these tiny bits of solid matter is capable of being altered when light strikes it, so that, although it shows no visible change, it will blacken and become a minute grain of metallic silver when acted on by the developer. A definite minimum amount of light is needed, and this quantity becomes a measure of the speed of the plate. Anything less than this intensity of light does not act enough on the particle and is called under-exposure. (Fig. 1.) If the light acts for just the right time, the number of particles affected and blackened in development is such that the tones form a negative record of the tones of the object, being

M. D. Miller

Fig. 3.—Extreme Overexposure, with Reversal of the Sun's Disc

black or opaque where the object is white, and transparent where the black occurs in the shadow. With such a correct exposure (Fig. 2), which, in the case of a good plate, may extend, let us assume, from 1 to 5 units of time, the tones are properly rendered and the print from the negative looks about as the object does to the eye. Beyond this arbitrary limit of 5, however, the increase of exposure affects more particles of silver bromide than are needed, and these blacken in development and cause the negative to look flat. (Fig. 3.) This is overexposure. The shadows have too much detail and print gray instead of black; the half-tones are as opaque as the highest lights and also print gray. There is no contrast between the tones. If one carries the process far enough, say several thousand times normal, the highlights become thinner and thinner, the shadows more and more opaque, until at last the image becomes positive instead of negative. This phenomenon is known as reversal of the image (Fig. 3 shows reversal of the sun), and occurs with all plates, except those prepared with hydrazine and marketed under the trade name of "Hydra" by an English firm. In these, the chemical named hydrazine prevents reversal and allows exposure of almost any duration to be given without the necessity of losing the plate from overexposure.

Correct Exposure. — To solve our problem, then, we must find the exposure between 1 and 5 — the "latitude" of a good plate or film — and then our negative will correctly represent the difference between the tones as seen by the eye. As different brands vary in sensitiveness to light, it is necessary to have some standard by which to compare them. This is found in the H. and D. numbers when all brands are exposed to the same standard light and developed with the same developer; but since no two makers employ identical materials and methods it is not possible to compare one maker's H. and D. speed numbers with those of another maker.

How H. and D. Speeds are Found. — The exposure apparatus of Hurter and Driffield consists essentially of a rotating sector disc which revolves in front of the plate and exposes it in bands so that the exposures of the different bands are in geometrical ratio. An exposure of convenient duration is given, and the plate is then developed in a standard developer for a certain time at a certain temperature. The fixed negative shows a series of strips extending from the faintest deposit of silver (underexposure) to maximum density and beyond this to beginning reversal. It is then placed in another piece of apparatus in which the densities of the de-

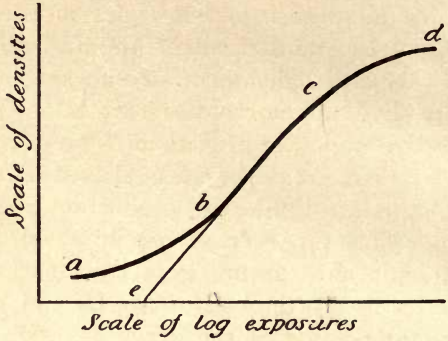


Fig. 4.—A Typical H. & D. Curve

posits are read off and the results are plotted out on co-ordinate paper, the densities as ordinates or vertical distances, and the logarithms of the exposures as abscissæ or horizontal distances. See Fig. 4.

The first part of the curve, *a* to *b*, is concave upward and represents the period of underexposure. The straight portion of the curve, *b* to *c*, is the period of correct exposure, or latitude, and exposures anywhere within the limits traced by the straight line will give good, printable negatives, with accurate differentiation between the tones, though the general opacities or densities will increase with added exposure. That is, if the correct exposure extends from 1 to 5, the negative given 5 will be denser throughout than that given 1, but the relations between the different tones will be the same, though the times needed to take off a print are widely different. The moment, however, exposures in excess of 5 are given the period of overexposure begins, the straight line becomes a curve, *c* to *d*, and reaches a summit only to drop rapidly away, the last portion being omitted in our cut. The density of the deposit of silver lessens because of reversal, as the grains of silver bromide which have received excessive light action are no longer reduced fully and some are not reduced at all. The latter remain in the yellow state and the plate is said to be solarized. Fixing removes the unaltered bromide and the highlights are thinned in proportion to the over-exposure. This property of partial reversal of the highlights is a most useful one, as we shall see later; but now let us see the end of our H. and D. curve. The straight portion of the curve is produced until it cuts the base line at *e*, and the value found at this point is called the inertia of the plate. The greater the inertia, the slower the plate. The speed of the plate, or H. and D. number, is found by dividing 34 by the inertia. This value is also often called the actinograph number, as it is used with a calculator sold abroad under the name of the actinograph. From the true H. and D. number the Watkins and Wynne speed numbers are calculated.

At this point it may be as well to emphasize the fact that most makers of plates do not follow the standard conditions laid down by the original investigators, owing to differences of opinion among scientists as to standard lights, or for other reasons.

Independent Standards. — Watkins numbers can be relied on, because the Watkins Meter Company is in an absolutely independent position and has no interest in overstating the speeds — a temptation which has led some of the platemakers to exaggerate, or to adopt some modification of the H. and D. method of speed testing which shall give very high readings. For example, some firms give H. and D. numbers which are very low, and the Watkins speed has to be found by multiplying them by $1\frac{1}{2}$ or even by 2 — the method used by the Watkins people. Other makers, on the contrary, claim H. and D. numbers much higher than the correct Watkins ratings. The first may list a plate as H. and D. 125; the second may rate a plate of exactly the same speed as H. and D. 400. In fact, one cannot rely at all on H. and D. numbers as used by platemakers. On the other hand, one may think the Watkins numbers err on the side of conservatism; but when all is said, one is more liable to lose a plate through undertiming than any other error whatsoever, so it is a positive advantage to know what good, full exposure is. It is easy to give less, if desired; but it is impossible to bring out in development any details which have not been sufficiently exposed. Hence, if any reader thinks the exposures we recommend (calculated by the Tables given herewith, or by the published Watkins or Wynne numbers) are too great, let him stick to the published speed rating and simply give a shorter time, as experiment and his personal taste may dictate. The writer's own allowance outdoors for average landscapes is half the full Watkins Bee meter time, to compensate for the high efficiency of an expensive shutter having accurate, tested speeds. Indoors, the full time is given. A similar allowance may be made from the Table times without getting serious underexposure.

Equivalent Plate-speed Numbers. — The following table indicates the corresponding speeds of different systems.

A. P.	Watkins.	Wynne.	A. P.	Watkins.	Wynne.
½	500	F 156	5½	16	F 28
1	350	F 128	6	11	F 22
1½	250	F 111	6½	8	F 20
2	180	F 90	7	6	F 16
2½	130	F 78	7½	4	F 14
3	90	F 64	8	3	F 11
3½	65	F 56	8½	2	F 10
4	45	F 45	9	¾	F 9.5
4½	32	F 39	9½	1	F 8
5	22	F 32			

Correct Exposure and Printing Quality. — As we have seen, correct exposure is a variable quantity extending from a minimum useful amount to one several times as great. The statement of the case in the words of Mr. Vero C. Driffield* may be of assistance. "I have in my possession two negatives of the same subject taken upon the same plate and developed together for the same length of time, but the latitude of the plate used was such as to permit of one negative being exposed for ten times as long as the other. While one of the negatives has every indication of a perfect exposure, the other gives to the eye the impression of heavily fogged overexposure; yet they yield identical prints. The time occupied in printing, however, while quite normal in one case, amounts to two or three days in the other. My object in mentioning this is to point out that a photographer who might inadvertently produce such a negative as the denser of these, would, from its behavior in the developer, probably conclude that he had enormously overexposed. He would at once stop development,

* The Photo-Miniature, No. 56, page 385.

reconstitute his developer, and, on taking a print from the finished negative, flatter himself that the result was due to his skill in development, while, as a matter of fact, the gradations of his negative were true from the outset. In the instance referred to, the image of the denser negative flashed up in the developer far more rapidly than that of the other, and by the time development was completed it was lost in an apparently impenetrable deposit of high density. From this, it is obvious that a system of timing development by the first appearance of the image is fallacious; and, had it been resorted to in this instance, the two negatives would never have yielded identical prints. When two negatives, such as those described, yield identical prints, their density differences are alike throughout, though the density ratios differ."

Why the H. and D. Numbers must be Checked by Test. — It has always been evident that speed numbers found by any artificial-light test must be corrected by actual trial for daylight exposures. The difficulty is largely due to the color-sensitiveness (or lack of it) of different emulsions, so that, for instance, an ortho plate may give an absurdly low H. and D. number and its speed, for practical purposes, has to be determined by camera exposures. The necessary correction is made by the authors of speed lists, who convert the true H. and D. number to their own system and prove its correctness by camera exposures outdoors. The plate number, in any system, may be regarded as the regulator, to be set faster or slower by the user to suit his own particular notions of just what exposure he wishes. Something, of course, depends on the development, and we cannot too strongly urge the standardization of this element by the use of the Thermo system of development, by means of which all variations in temperature, etc., may be compensated for very exactly and a standard amount of contrast between the tones always be obtained with precision. The system is described in full in *The Watkins Manual* (price 60 cents, from our publishers), and suitable tables are furnished by us in card form for darkroom use for 25 cents.

Another reason for checking speeds by trial is that practically all of the ultra-rapid plates (our Class $\frac{1}{2}$) are abnormal in their characteristics, as compared to slower emulsions. They are intended chiefly to utilize the underexposure portion of the H. and D. curve, and it will be found that when the lowest tones (clear-glass shadows) fall very close to the point where no light action can be demonstrated, the highlight details come rather low on the straight-line portion and give printable differences. If, on the other hand, these plates are given normal exposures, so as to bring the whole exposure on the straight-line portion, the upper tones suffer from "plugging up," that is, there are no printable differences between them. In practice, then, one finds that when these plates are used they must be very judiciously timed, avoiding any suspicion of overtime, and developed in a very concentrated solution. In speed work, particularly, with exposures of, say, 1–250 second with a Compound shutter or 1–600 and 1–1200 with a focal-plane shutter, the necessary general density for printing quality can only be obtained by special methods of development, such as the use of concentrated developer or a greatly prolonged time of development, not to mention special formulæ designed to stain the plate and thereby increase the non-actinic nature of the silver deposit. Speed work, however, is abnormal, for the first consideration must be to use a shutter speed high enough to " stop motion " and the second is to make the most of a known underexposure.

Watkins' Central Speed. — Mr. Alfred Watkins in a recent book, " Photography: Its Principles and Applications," describes a new method of finding a value which he calls the central speed of a plate. It corresponds to the middle point of the straight line, and of it Mr. Watkins says, " It may be said at once that this central speed method does not give the maximum speed of the plate, but the speed which indicates the exposure yielding the best possible results, and if the same emulsion is so coated on two plates as to give a thin film in one case (short period of correct exposure) and a thick film in another case (long period of correct exposure), the poorer film will indicate the higher speed. This is best when the speed is used for purposes of practical exposure, but a disadvantage from the point of the platemakers' competition to advertise the highest speeds for their plates.

" The writer is inclined to think that it may be advisable to make two speed tests of a plate: the first, made by an observation of the smallest exposure which gives a visible deposit, and to be called the maximum speed test, being right for snapshot exposures and advertising; the second, made by the central speed plan, being right for time exposures for best results."

From experience with Mr. Watkins' meter and the list of plate speeds supplied with it, we are inclined to think that the statements of Mr. Driffield and of Mr. Watkins may be harmonized as follows: Mr. Watkins gives numbers which we think represent his "central speed." The average user believes with Mr. Driffield and finds them too low, hence after trial adopts a Watkins plate speed number much higher than the one on the card and probably agreeing pretty closely with Mr. Watkins' "maximum speed." For example, if one were to take the speed of an average film as 90, as printed in a recent speed list, and give 1–45 second at *f*:8 with a light value of 2, the exposure would probably tend to produce the results so graphically described above by Mr. Driffield; whereas a speed number of 180, indicating an exposure of 1–90 second, would undoubtedly not give serious undertime and would yield a quick-printing negative suitable for most modern papers. In this example it is assumed that the shutter speeds are accurate. The same result is reached if one calculates with the printed number, 90, but *halves* the indicated exposure. The Focal Plane meter, however, indicates *half* the Bee exposure, to allow for snapshots and indicate the shortest possible full exposure. The same correction holds for the Wynne Snap Shot meter. In the same way, other films listed at 180 are found to give sufficient exposure in snapshot work if the speed number 350 be used in calculating. It is all a matter of actual trial to find what number gives the results desired by the individual. In fact, Mr. Watkins says in his instructions, under "Shutter Photography," that it "must be remembered that the indication is for *full* exposure (the one giving the best results), and that half this is as much as is generally possible to give under the circumstances; indeed, one-quarter the full exposure often passes muster as 'good for a snapshot.'"

Variations in Plate Speed. — Sometimes one batch of plates of a given brand will test twice as fast as another batch, owing to variations which it is beyond human skill to control. Hence, it is evident that no statement of the speed of a particular sort of plate can be anything but an approximation. Notwithstanding this drawback, the wise buyer who sticks to one kind seldom finds variation enough to upset his calculations, because so many other sources of error, such as inaccurate shutters, enter into the problem. As a general thing, plates of one brand will not depart from their average speed sufficiently to spoil one's results. In some factories, the finished plates are tested for speed and sorted into brands according to the readings obtained: all which reach the top speed being the high-priced brand, those which fall short, the next cheaper, and so on. This plan is to the advantage of the consumer, as far as uniformity of speed goes.

Variations in Shutter Speeds. — Perhaps the most disturbing variation of all is that of the exposure shutter. Few between-the-lens shutters come within a reasonable percentage of being accurate. A speed marked 1–100 second is almost never faster than 1–60 and sometimes far below that. The more expensive shutters are, however, accurate on some of their speeds. The only sure way to control results is to check the speeds by the average of a number of tests with some such simple device as the Wynne or Pickering Shutter Speed Tester. A careful worker will repeat the tests several times during the season, as temperature, dust, corrosion, and many other things may seriously alter the speeds. Most shutters also vary when used on their sides, that is, when the kodak is reversed to take a horizontal picture. The slower speeds, when retarded by an air pump, are notoriously inaccurate and undependable. The subject is too large to go into in detail, but the reader will readily appreciate that to know what he is doing he must test his own shutter and know how fast it works. As a rule it is quite immaterial what the speeds really are if one is informed of the actual values for each marking.

Efficiency of Shutters. — Another variation, as between shutters of different models or types, is due to the higher or lower efficiency of these instruments. When our Tables were first compiled, practically the only shutters were of a two-blade type and had an efficiency of about 50 per cent. The rather full times indicated by the Tables were intended to allow for this low efficiency, hence the user of a modern sector shutter, having from three to five blades and an average light-efficiency of about 85 per cent, will probably find it possible to use *half* the exposures indicated by the Tables and still get good, full exposure. The cheaper, old-style shutters, on the other hand, will generally need the full Table time.

Focal-plane shutters are generally stated to be 100 per cent efficient, but this is, of course, an exaggeration. Careful tests made abroad proved that ten commercial focal-plane cameras had an average efficiency of 85 per cent. However, many users do find in practical work with their reflecting cameras that they can give exposures as fast as one-quarter or one-sixth those called for by our Tables and still get satisfactory results. As the question is so often asked, we would suggest that each user of a focal-plane shutter make a series of trial exposures, giving half, one-quarter, one-fifth, and one-sixth the times of the Tables and select the best-printing negative. All future exposures can then be figured by the Tables and corrected by this factor. This, naturally, does not apply to speed photography, but only to determining the right shutter speed to employ in order to secure proper rendering of the shadows.

More about Underexposure. — Consideration of light action has shown us that there is a minimum amount of light needed to make silver bromide developable. If the exposure is regulated so that not enough particles are affected, or so that the particles are not affected enough to develop, the negative lacks detail throughout and shows but the ghost of an image. More, but still insufficient, exposure may give highlights and halftones full of detail (but denser), and blank shadows. A slight increase may give much more density in the lights and hints of shadow detail, the whole effect being extremely contrasty. Such a negative gives a "soot and whitewash" print, because the dense highlights cannot be printed through before the shadows are buried in blackness. Finally, we may discriminate against a plate as underexposed if any portion of the shadow detail is quite bare glass, it being presumed that all objects in nature reflect some light to the eye and also affect silver bromide. It will teach the reader more about exposure to expose a series of plates on the same subject, giving times running from say $\frac{1}{8}$ normal to normal, and developing them together for the same length of time than could be learned in any other way. Exposure should be regulated by the stop, the same speed of shutter being used throughout. The gradual building up of contrast with increasing deposits of silver in the lights and the attainment of maximum useful density are thus clearly brought out.

More About Correct Exposure. — Continuing the series of exposures recommended in the last paragraph, one can give more time to each succeeding plate and note the latitude, remembering to judge by the print, as pointed out by Mr. Driffield. It will generally be found that few rapid plates will stand more than six or eight times the lower normal exposure without rendering the gradations of tone wrongly; in other words, they have reached the limit of their latitude and are overexposed. The experimenter will note the decrease of contrast between highlights and shadows, the running together into one uniform grayness of the highlights and the halftones, and the clogging up of the shadows with superabundant detail.

Latitude. — Latitude varies directly as the quality of the plate. Cheap plates are invariably poor in silver, and though they may seem to be rather rapid, they have so thin and impoverished a film that they develop through to the back very quickly and yield only a weak negative. No treatment will cause them to build up a rich, contrasty, well-graded negative. A short exposure fails to impress the shadow detail; a correct exposure gives somewhat veiled or foggy shadows; double or triple the shortest normal time produces a flat, lifeless, overtimed result. When one pays only a few cents a dozen more, one gets better glass, and a thicker, richer film, with greatly increased latitude and better quality throughout. Other things being equal, the thicker the film, the greater the latitude. Double-coated plates, therefore, which have a very rich, opaque, slow emulsion next to the glass and a rapid one coated over it, possess enough latitude to handle the most difficult kinds of subjects, such as interiors with sunlighted landscapes showing through the open windows. Ordinary plates and films, though quite efficient for average subjects, are not capable of handling the extreme contrasts presented by such subjects. Hydra plates will surpass even the double-coated, in difficult cases, but ordinary plates often cannot be exposed correctly for all the tones, and a compromise must be found which will render most of the values accurately enough to suggest the original in a well-made print.

Latitude also varies considerably with speed. The ultra-rapid plates of our Class ½, equivalent to Watkins 500 or Wynne F 156, are designed particularly for extremely short exposures. They utilize, in fact, practically only the underexposure portion of the H. and D. curve. If they are given full time, the results do not show such good general quality as can be obtained with a Class 1 or a Class 1½ plate. The ultra-rapid plates are generally markedly sensitive to red, hence are easily fogged by common ruby dark-room light. They have poor keeping qualities. They tend to give chemical fog or surface markings and mottling when affected by age, moisture, or heat. They have so little latitude that the exposure must be determined with the utmost exactitude or the results will be weak, flat, and characterless. Still, in their particular field, when only the most rapid plate possible will answer, they are excellent.

Modern films (and their equivalent, the double-coated, orthochromatic plate) have great latitude, with speed enough for most requirements, and will be found very satisfactory.

Correct exposure, then, we may conclude, is that which renders the relative gradations of tone as they appear to the eye — barring orthochromatic rendering, which is "another story," as Kipling says. Incorrect exposure, as we have seen, gives false contrasts, but it must not be thought that it is the function of exposure to regulate contrasts, except as the pictorial worker aims to alter them for his artistic purpose. The chief concern of exposure is to secure a record of the different amounts of light reflected from the objects in front of the lens — to give a true rendering of the relative lightness or darkness of each tone. Once this is secured, automatic development for exactly the time found right by experiment will give the amount of contrast seen by the eye (except for non-orthochromatic rendering).*

It is apparent that nothing which can be done to the plate in the darkroom has a great deal of effect upon it as compared to the exposure which went before. The fate of the picture has been sealed when the shutter has closed and the kodaker turns the key to wind on a fresh section of film. The one important problem in taking every picture is "How much time shall I give?" Let us now consider means to solve this problem.

* See the Thermo Card, sent postpaid for 25 cents by our publishers.

A Practical Guide to Correct Exposure. — A number of years ago, F. Dundas Todd, editor of *The Photo-Beacon*, drew up a series of tables based on exhaustive experiments and checked by repeated practical tests in the field. His idea was to assign to each element concerned an arbitrary number, to add together the appropriate numbers, and from their sum to determine the necessary exposure. We reproduce herewith these tables in their latest form, and the interested reader will find them each month in both *American Photography* and *Popular Photography* with new plates listed as they are introduced, and changes in speeds made as needed. They may also be had from our publishers in pocket form, with an exposure record, for 25 cents, postpaid.

The American Photography Exposure-Tables.* — Find numbers for subject, stop, light, month and hour, and plate. Add them, refer to table (page 28), and give exposure indicated. When the exposure fails to correspond with speed marking on shutter, use the nearest shutter speed, preferably the lower.

Subject. —

Sea (only) and clouds	½
Sea views, snow scenes, distant landscape	1
Open landscape with unimportant foreground	2
Average landscape with foreground	3
Landscape with dark foreground, groups in sunlight	4
Street scenes, buildings, groups	5
Portraits in shade	7
Indoor portraits	8 to 10
Interiors	8 to 16

Stop. —

f.	2	2.3	2.8	3.3	4	4.7	5.6	6.7
U. S.	0.25	0.33	0.5	0.7	1	1.4	2	2.8
Number	**1**	**1½**	**2**	**2½**	**3**	**3½**	**4**	**4½**
f.	8	11.3	16	22	32	45	64	
U. S.	4	8	16	32	64	128	256	
Number	**5**	**6**	**7**	**8**	**9**	**10**	**11**	

Light. —

Intense sunlight (inky-black shadows)	0
Bright sunlight (strong shadows)	½
Faint shadow cast by sun	1
Dull (no shadows)	1½
Very dull (whole sky very dark)	2

If sunlight falls over one shoulder, add 0; if straight across subject, add 1; if sun is ahead, add 2 (see Fig. 17). When using back combination only of R. R. or symmetrical lens, add 2, unless actual *f* value of stop is known and used.

Month and Hour. — (For latitude 40° N.)

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		0	0	0	½	½	1	1
11	1	0	0	0	½	½	1	1
10	2	0	0	½	½	1	1½	1½
9	3	½	½	½	1	1	2	2
8	4	1	1	1	2	2	3	4
7	5	1	1½	3	4	5	5	5
6	6	2	3	4	.....	.....	.....	.....
5	7	5	.....	.....	.....	.....	.....	.....

Plate. — *Nota Bene.* — The numbers indicate exposure factors for use with our Tables and the letters development speeds for Thermo Development.

American —

Extra Rapid	1½	

Ansco —

Film and Pack	1½	S
Speedex Film	1	VS

Barnet —

Film	1½	S
Superspeed Ortho	1	M
Ortho Extra Rapid	2	MS
Red Seal	1	M
Red Diamond	1½	MS
Self-screen Ortho	2	MS
550	½	S

Burke and James —

Atlas Film	1½	S

Central —

Special XX	½	VS

Special Home Portrait	½	S
Special	1	M
Special Non-halation	1½	MS
Comet	1½	M
Colornon	1½	MQ
Panortho	1½	MQ
Cramer —		
Crown	1	S
Anchor	2	MQ
Banner X	1½	S
Instantaneous Iso	1½	MQ
Medium Iso	2	MQ
Commercial Isonon	2½	MQ
Portrait Isonon	1	M
Trichromatic	2	MQ
Slow Iso	5	MQ
Contrast	9	VVQ
Spectrum	2	MQ
Defender —		
Vulcan Film	1½	S
Vulcan (Plate)	1	M
Ortho	2	MQ
Non-halation Ortho	2	MQ
Slow	9	VVQ
Process	9	Q
Dufay —		
Dioptichrome (with filter)	7	
Eastman —		
Motion-picture Film	1	MS
Portrait (flat) Film	1	MS
Speed Film	1	VS
Graflex Film	1	VS
Hawk-Eye Film	1½	S
N. C. Film	1½	S
Ensign —		
Film	1½	MS
Forbes —		
Challenge	1½	VQ
Snapshot	1½	Q
Hammer —		
Special Extra Fast (Red Label)	1	MS
Extra Fast (Blue Label)	1½	M
Aurora Extra Fast	1½	MS
Ortho Extra Fast	1½	M
Ortho Non-halation	2	M
Fast	2	MQ
Ortho Slow	2½	VQ
Slow	4	VQ
Ilford —		
Monarch	1	VS
Zenith	1½	VS
Special Rapid	2	VS
Chromatic	2½	Q
Rapid Chromatic	2	M
Ordinary	3	Q
Process	9	
Imperial —		
Flashlight	1	M
Special Sensitive	1	MQ
Orthochrome Special Sensitive	1	MQ
Special Rapid 225	1½	S
Duonon	1½	MQ
Special Rapid 200	2	S
Non-filter	2	MQ
Process	9	
Jougla —		
Violet Label	1½	
Green Label	2	
Omnicolore (with filter)	7	
Kodak —		
Speed Film	1	VS
Graflex Film	1	VS
N. C. Film	1½	S
Kodoid Plate	1½	S
Hawk-Eye Film	1½	S
Motion-picture Film	1	MS
Portrait (flat) Film	1	MS
Lumière —		
Sigma	½	S
Blue Label	1½	MQ
Film	1½	S
Ortho A	2	M
Ortho B	2	MQ
Panchro C	2	MS

Autochrome (Outdoors)	7½	
Autochrome (Indoors)	8½	
Slow	9	MQ
Marion —		
Record	½	S
Brilliant	1	S
P. S.	1	MS
New Record —		
Extra Fast	2	VS
Paget —		
XXX	2½	M
XXXXX	2	MS
Swift	1	S
Extra Special Rapid	1	S
Ortho Extra Special Rapid	1½	MQ
Panchro Ordinary	2	Q
Panchro Color (no screen)	2½	VQ
Special Rapid	1½	S
Hydra Panchro	3½	MQ
Hydra Rapid	3½	MQ
Premo —		
Filmpack	1½	S
Speed Pack	1	VS
Roebuck —		
Blue Label	1	S
D. C. Ortho	2	MQ
Ortho	2	MQ
Rogers —		
Regular	1	S
Orthochromatic	2	MQ
Ortho Non-halation	2	MQ
Seed —		
Graflex	½	S
Gilt Edge 30	1	MS

Color Value	1	M
Gilt Edge 27	1½	MS
L Ortho	1½	MQ
26 X	2	MS
Non-halation	2	MQ
Non-halation L Ortho	2	MQ
Tropical	2	M
C Ortho	2½	VQ
Panchromatic	2½	VQ
23	3	MQ
Process	9	
Standard —		
Extra	1½	MQ
Imperial Portrait	1½	MQ
Orthonon	1½	MQ
Polychrome	1½	MQ
Thermic	1½	MQ
Stanley —		
50	1½	M
Commercial	4	MQ
Wellington —		
Extreme	½	S
'Xtra Speedy	1	MS
Film	1½	M
Iso Speedy	1½	M
Portrait Speedy	1½	M
Anti-screen	1½	M
Speedy Special Rapid	2	MS
Ortho Process	9	M
Wratten & Wainwright —		
Panchromatic	1½	MQ
Process	3	Q

N.B. — Process plates are usually exposed as if they were Class 4½ to Class 3 when used for copying line drawings.

Plate Speeds. — The plate factors are intended to indicate a fair average value for each brand so that users will be sure of giving proper (full) exposure if they follow the tables. It is a well-known fact, however, that plates vary in speed, the tendency of most brands being to become faster as years pass. Two boxes of the same brand, sometimes of the same batch, will occasionally vary 50 per cent or more in speed.

Exposure. — The following table shows the exposure corresponding to the number found by adding the five factors.

3½ S 1/5000	4 S 1/4000	4½ S 1/2500	5 S 1/2000	5½ S 1/1250
6 S 1/1000	6½ S 1/700	7 S 1/500	7½ S 1/350	8 S 1/250
8½ S 1/150	9 S 1/100	9½ S 1/75	10 S 1/50	10½ S 1/40
11 S 1/25	11½ S 1/20	12 S 1/12	12½ S 1/10	13 S 1/8
13½ S 1/5	14 S 1/4	14½ S 2/5	15 S 1/2	15½ S 2/3
16 S 1	16½ S 1½	17 S 2	17½ S 3	18 S 4
18½ S 5½	19 S 7½	19½ S 11	20 S 15	20½ S 23
21 S 30	21½ S 45	22 M 1	22½ M 1½	23 M 2
23½ M 3	24 M 4	24½ M 6	25 M 8	25½ M 12
26 M 15	26½ M 24	27 M 30	27½ M 45	28 H 1
28½ H 1½	29 H 2	29½ H 3	30 H 4	30½ H 6

Caution! — Avoid underexposure, and, in case of doubt, give more than the Tables indicate rather than less. Underexposed films will never give satisfactory prints, but any reasonably full exposure will give a good print if fully developed.

An Example. — Let us suppose a case. You are about to photograph an

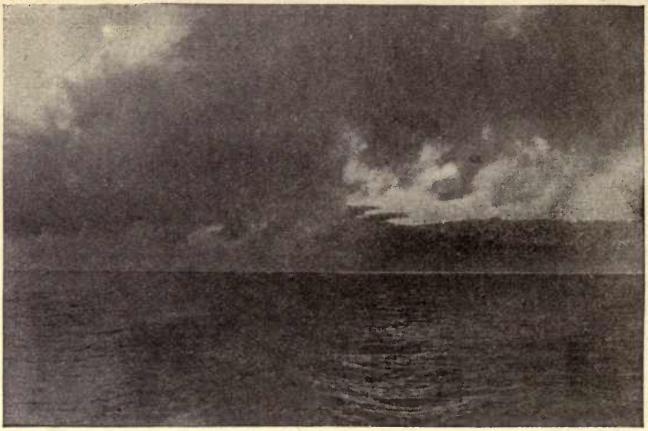
Average landscape	3
Using stop *f*:11 (U.S. No. 8)	6
Light is intense	0
Time, 11 A.M., in July	0
You are using Eastman N. C. film	1½

The figures given are those to be found in the Tables opposite the different conditions. Adding them together we get 10½ as the total, and on referring to the last table under 10½ we find 1–40 second, which is the exposure to give.

Referring to the instructions on page 24, the reader will observe that there are five elements or factors necessary to consider in determining exposure by these Tables. They are: subject, stop, light, month and hour, and plate. Let us consider them a little more in detail.

The Influence of Subject. — The Tables separate all possible pictures into eight groups having arbitrary values from ½ to 16; that is, requiring exposures from the most rapid snapshots to prolonged time-exposures indoors. The division is based principally upon the amount of actinic light which is reflected from the subject.

"Sea (only) and clouds" (Fig. 5) is the group requiring the least exposure, on account of the great brightness of the sky, which is a secondary source of



F. R. Fraprie

Fig. 5.—Sea only and Clouds

light, owing to refraction of the sun's rays from dust particles or water vapor, reflection from clouds, and the throwing back of most of the light from the water, the color of which is extremely actinic as well; so that overexposure is the commonest mistake made by the beginner. There should be no difficulty in telling whether a given view comes in this group, for the use of the word " only " rules out all other seascapes which contain objects such as ships within 100 ft. Red or yellow sunrise or sunset clouds require more exposure unless a color-sensitive plate is used. Very faint white clouds take half, and very dark storm clouds twice the exposure.

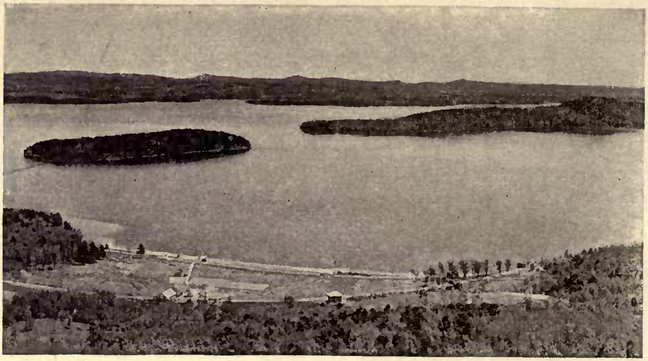
" Sea views (Fig. 6), snow scenes or distant (panoramic) landscape," is the next group. The factor is 1, showing that this class requires 50 per cent more time than the preceding group. Here we may include all seascapes which have ships or yachts near enough to

A. Schnutenhaus

Fig. 6.—Marine View

Forman Hanna

Fig. 7.—Snow Scene



Maynard J. Ames

Fig. 8.—Distant Landscape

be of importance in the composition — say within 100 ft. in the case of large ships or 50 ft. in the case of yachts and small boats. Views on open beaches or on river banks open to the sky and away from trees or buildings, open snow scenes with no dark objects (Fig. 7), and any other subjects in which the principal objects are 100 ft. or more away from the lens, with a flat, well-lighted foreground, may be classed as 1.

By "distant landscape" (Fig. 8) is meant one taken from an elevation and including nothing in the foreground; that is, the actual middle distance of the view is the foreground of the picture. Such subjects are usually spoken of as panoramas, and most objects are miles distant from the lens. Most telephoto subjects come in this group, as well as aeroplanes in flight.

"Open landscapes with unimportant foreground," factor 2 (Fig. 9) is the next group. The difference between the groups having factors of 1 and 2 is this: In class 1 everything is at least 50 ft. or more from the lens. If one goes close enough to the principal object,

M. D. Miller

Fig. 9.—Open landscape, Unimportant Foreground

say 25 ft., the subject would become 2, and would require good rendering of shadow detail by an increased exposure. The foreground, however, is flat and has no marked shadows; hence it hardly counts in settling the exposure. The moment any dark objects come within 25 ft., whether they are human or animal figures, small trees or bushes, or shadows cast by objects outside the field of view, we should have to pass to the next class, value 3. It is the important objects near the lens or the shadows in the foreground which have to be noted most carefully. This group includes open landscapes, streets, fields; light-colored buildings in landscape; men or animals in the middle distance; athletic sports from spectators' benches; beach scenes with dark or near foreground objects; ships and

M. D. Miller

Fig. 10. — Average landscape

yachts in dock or close to the camera; average snow scenes with tree-trunks or other dark objects within 25 feet.

"Average landscape with foreground" (Figs. 2 and 10), value 3. This is the largest class of subjects likely to be taken by the beginner. The deciding point is that the main interest and the principal object of the picture are centered in the foreground, or the color of the latter is dark, whether owing to shadows cast across it or to the deep tone of the materials of which it is composed. Most of the vacation snaps of parties attempted by the kodaker fall within this group, the subjects being posed in full sunlight 15 ft. or more from the lens. The moment one goes closer, say to 8 ft., the exposure would need to be doubled. Many street scenes of an open nature should be

M. D. Miller

Fig. 11.—Landscape with Dark Foreground

classed as average landscapes. Class here all landscapes with foliage, figures, or buildings of average color; average street scenes in wide streets or open squares (not narrow canyons of city streets); full-length figures or groups open to sky; views with the principal object about 25 ft. from lens.

" Landscape with dark foreground," factor 4 (Fig. 11). This group is the same as the last, except that the foreground is darker in color, or is in shadow, or the principal object is dark and nearer the lens than 25 feet. It includes most city street scenes with shaded foreground. It is always a good plan to use this value in place of 3 if the foreground is in shadow.

" Street scenes, buildings, groups " (Figs. 1, 12, 13, 14), value 5. A typical street scene is one where there are houses on both sides of the way, and the light is

M. D. Miller

Fig. 12.—Street Scene

confined to a relatively narrow strip of sky. Where the buildings are higher it may be necessary to give even more time than denoted by the number 5, as in the canyons formed between modern skyscrapers. Buildings come in this group only when they are near and form the main part of the picture.

A group is generally posed about 12 or 15 feet from the lens on steps in the full shade of a building and not open to much sky light. Details of architecture, such as piazzas, doorways, etc., may be placed here; also full-length figures in the shade. (Fig. 15.)

"Portraits in shade" (Fig. 16), value 7. A portrait is a subject which requires a considerable exposure as compared to a landscape. Take as an example a man standing in the shade of a house. If he were photographed full length with the ordinary

W. L. F. Wastell

Fig. 13.—Building

M. D. Miller

Fig. 14.—Group

Frau Clara von Wätjen

Fig. 15.—Figure in Shade

outfit, he would count as 5; but as soon as one goes close enough to make the head and shoulders fill the picture space, the exposure must be greatly increased. Single meniscus lenses, working at f:16, are not capable of making snapshots of such subjects without appreciable underexposure; but a bulb exposure will generally yield a good result, say about ½ second. "Portraits" here is taken to mean head-and-shoulder pictures, and half-length studies. In this class belong studies of dark foregrounds very close to the lens, or fruit, flowers, etc., in shade outdoors and only 5 or 6 feet from the lens.

Wm. R. Read, Jr.

Fig. 16.—Portrait in Shade (Artificial Background)

Groups consist of two or more persons at such a distance from the camera that the figures nearly fill the picture space. If the same persons were taken at a greater distance, the subject would be classed as a landscape. Groups are usually posed in the shade, as on a porch open to the sky, or under trees, and hence require a long exposure owing to the lessened illumination. Groups in full sunshine may be taken with a large stop and a slow snap. They often fall in Class 4.

"Indoor portraits," value 8 to 10. These figures refer to home portraits taken by an ordinary window.

If the light is brilliant, the subject near the window, the surroundings very light in color so as to reflect a great deal of light, a white reflector used, and the sitter dressed in white or light colors, the value 8 would be chosen. A dark room, small window, and dark clothes would naturally cause one to calculate with a value of 9 or 10. Exposure in such cases is a matter of seconds and will vary with local conditions, hence the value of this class may be changed by the worker if trial exposures make an alteration seem desirable.

"Interiors," value 8 to 16. As in the case of portraits, the individual room may be so much brighter than the one represented by 16 as to require the use of a different number. Here again, careful tests by actual exposures will give the photographer the best idea what number to use for similar conditions of lighting in other rooms. Exposures may run from a few seconds to several hours in different interiors, such as a dainty boudoir or a gloomy church. The general color of the room has a tremendous influence. Double-coated ortho plates will be found most generally useful.

The reader will have noted that in this system of exposure by tables the accurate placing of the subject is of great importance. The subjects requiring the least exposures are those of highly actinic color or far distant from the lens, so that the veil of luminous atmosphere partly obliterates the local color and introduces rays from the violet end of the spectrum. These subjects, it may also be noted, have relatively little contrast between the tones. As a general rule, all objects distant more than 24 times the focus of the lens require the same exposure. For a $6\frac{1}{2}$-in. lens on a 3 A Kodak, this distance is 13 ft. Let us trace the influence of distance in the case of a single man. At 25 ft. he would count as part of the landscape and be called average landscape with foreground. At 13 ft. he would fall into the class of street scenes, buildings, groups; at 6 or 7 ft. portraits in shade would be suitable — all this while the subject stood still and the camera was moved towards him.

Part of the difference just noted is due to the effect of distance and part to the fact that objects reproduced on a large scale require finer rendering of detail, particularly in the shadows, to satisfy the eye. In painting, for instance, one might represent a gray horse in the middle distance by a single brushful of paint, loosely put on and dragged roughly into shape; but if one were representing the horse in the foreground, it would have to be carefully and minutely drawn and colored. Contrast increases as the layer of air between lens and object diminishes. The greater the contrast, the fuller the exposure should be. "Expose for the shadows and develop for the highlights."

Orthochromatic Effect. — To some extent, the judgment of exposure must depend on the sensitiveness of the plate to different colors. Red, orange, yellow, yellow-green, and green affect plain (non-orthochromatic) plates only as they reflect ultra-violet and blue light. Blue-green, the color of most summer foliage, is particularly slow to impress the plate. Thus most photographs record the relative brightness of the objects in a scene quite incorrectly, being sensitive chiefly to the invisible ultra-violet and the visible violet and blue-violet. These facts explain why it is necessary to give a great deal of exposure to get the detail in dark-green foliage near the lens, because the amount of ultra-violet reflected diminishes with the nearness of the object and the local color itself hardly affects the plate at all. Orthochromatic (or isochromatic) films and plates are sensitive to the yellow and the yellow-green, but almost totally insensitive to blue-green, and hence the user has to keep in mind the color of the foliage and modify exposure accordingly.

Exposure with a Rayfilter. — When a color-screen or rayfilter is used, the exposure must be increased in proportion to the depth of tint of the filter. Screens are usually sold as " three-times," " four-times," etc., the maker furnishing the proper multiplying factor. If one desires to get the best possible results, it is wisest to test the supposed factor by actual trial. Make a series of exposures, giving factors both higher and lower than the supposedly correct one and choose the best-printing negative. A given filter may be a 2× with one make of ortho plate and a 4× or even 6× with another. In this connection, it is well to state that the low-priced yellow-brown-glass screens are not worth using. Better pay a fair price and get a spectroscopically adjusted screen, preferably one made of Filter Yellow K and requiring about 2 to 4 times increase of exposure. Old filters generally bleach after long exposure to light and therefore become quicker, or else turn brown and become slower.

The Influence of Excessive Contrast. — Some subjects cannot be accurately exposed for all portions because of the tremendous difference in the luminosities of the different parts. Thus, in landscape, the sky is overtimed if the dark foliage in the foreground be given enough time; or if the exposure be cut to save the clouds, the shadows are painfully blank. It is all a case of compromise, at best; and the single-coated plate cannot compete with the double-coated in handling contrasts. The old "golden rule of photography" must be borne in mind: "Expose for the shadows and let the highlights take care of themselves." Then, if one "develops for the highlights and lets the shadows take care of themselves," the rendering will be as good as the particular brand of plate can give; but failure is sure to occur if subjects having excessive contrasts are attempted.

Partial Reversal. — When a plate is fully timed, the sky becomes somewhat thinner, owing to its being overtimed and thereby partly reversed; but too long an exposure will yield a flat, gray, muddy effect as the reversal proceeds too far.

The Stops. — Two methods of marking the apertures of the lens are in common use, the *f* or focal fraction, and the U. S., or Uniform System, numbers. The *f* system is based on the diameters of the openings. For example, a lens has a focus of 8 in. and a stop 1 in. in diameter. $8 \div 1 = 8$, and the stop is marked *f*:8. A stop having half this diameter, or $\frac{1}{2}$ in., would have a value of $8 \div \frac{1}{2}$, or 16, and the stop would be *f*:16. The relative exposures with these openings, however, are not in the ratio of 8 : 16 or 1 : 2. The exposure with a given opening depends on its *area*. Now, the areas of circles are proportionate to the squares of their diameters. The square of 8 is 64 ($8 \times 8 = 64$) and the square of 16 is 256 ($16 \times 16 = 256$); hence, the ratio is 64 : 256, or 1 : 4. Hence *f*:16 requires four times the exposure needed for *f*:8. In practice, the *f* system is simplified by choosing apertures such that each smaller one shall have half the area of the preceding and thus require double the exposure. The series usually chosen is:

f:4 *f*:5.6 *f*:8 *f*:11 *f*:16 *f*:22 *f*:32 *f*:45 *f*:64

The Uniform System starts with *f*:4 as a basis and calls it U. S. 1. Thus the corresponding values are:

U.S.1 U.S.2 U.S.4 U.S.8 U.S.16 U.S.32 U.S.64 U.S.128 U.S. 256

The supposed advantage is that the stops requiring doubled exposures are also numerically double the preceding ones; but no one who has learned the *f* system finds the slightest difficulty in remembering the relative exposures. Most cameras and kodaks fitted with rapid rectilinear lenses are marked with Uniform System numbers. The important thing is always to say whether an *f* or a U. S. number is intended in stating data of pictures. It would be a gain in scientific accuracy of thought and speech if the U. S. numbers were abandoned and only the *f* numbers used hereafter. The tendency seems this way, owing to the almost universal marking of anastigmat lenses with *f* numbers.

Other *f* Systems. — Several foreign manufacturers have at different times used focal fraction stop markings based on some other stop than *f*:4 as a starting point, so that such odd values as *f*:18 or *f*:19 may be found on their lenses. We cannot too strongly deprecate the multiplication of systems of stop marking. The standard English *f* system, as described, is adequate, and it should displace all others.

The nearest regular *f* number given in our list of stops will in most cases come near enough to any odd *f* number, as a difference of less than 50 per cent in exposure is hardly demonstrable.

How to Find *f* Values. — Roughly, the *f* number of the stop may be found by measuring its diameter and dividing this number into the focus. Precisely, it may be ascertained in the following manner, prescribed by the Royal Photographic Society: The lens is focused on an infinitely distant object, the ground glass removed, and an opaque screen pierced with a pinhole in the axis of the lens is substituted. An illuminant is placed close to the pinhole and the diameter of the beam of light measured where it leaves the surface of the front lens. This diameter is the measure of the effective aperture.

Finding the Focus. — The equivalent focal length is found well enough for practical purposes by focusing on infinity and measuring from the diaphragm to the surface of the plate or film. Divide this measurement by the diameter of the beam of light and the answer is the *f* number of the stop. A more precise method is to focus an object exactly " same size " and divide the distance from ground glass to object by 4 to get the equivalent focus. This is not practicable with a short-bellows camera, of course.

Grubb's Method. — The easiest as well as the most accurate way to determine the focal length of a lens is that originated by Grubb. It may be used with a film camera by temporarily fixing a ground glass with its ground surface in contact with the aluminum rollers over which the film is drawn. On the ground glass draw two vertical lines about 1 in. from the margin at each side. Now set up the camera on a large table in front of a window and place a sheet of white paper

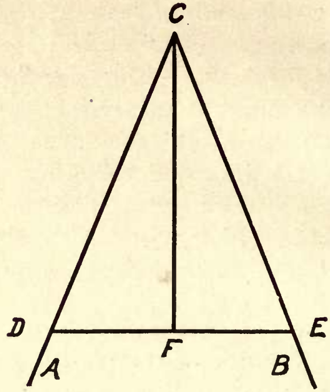


Fig. 17.—Finding Focal Length

under it. Focus on a chimney or church spire on the horizon and make the image fall upon one of the pencil lines. Now draw a pencil line *BE* upon the paper along the side of the camera and then turn the camera until the image falls upon the other line, when a second pencil line *AD* is drawn as before. After this, remove the camera and prolong the lines until they intersect, making an angle at *C*. Now measure the distance between the pencil lines upon the ground glass and lay off this exact distance *DE* so as to form the triangle *DEC*. See Fig. 17. Find the exact center *F* of this base line and draw *FC*. The length of *FC* is then the equivalent focus of the lens.

In the case of cheap cameras fitted with single lenses the stops of which are not numbered or are marked with arbitrary numbers from 1 (largest opening) to 4, the *f* values are found by measuring from the stop to the film and dividing this number by the diameter of the stop. It will probably be found that the largest stop in such a case is between *f*:12 and *f*:15. Suppose it to be *f*:14. How may one use such a value with the Tables? Let us compare it with *f*:11. Eleven squared (11 × 11) equals 121. Fourteen squared (14 × 14) equals 196. These numbers are to each other (approximately) as 1 : 1.5, hence *f*:14 will require 1.5 times as much exposure as *f*:11. In other words, it is 50 per cent slower. Now, in the tables, *f*:11 and *f*:16 are represented by 6 and 7, respectively, hence a good value for *f*:14 would be 6½. A value within 50 per cent is sufficiently close to be cared for by the latitude of the plate, in most cases.

Variation of *f* Values. — When the lens is extended in copying or enlarging, the actual working focus of the lens is increased so greatly that the *f* number is altered. Even in taking near objects, say at 6 ft., this diminution of the effective aperture of the stop has to be compensated for, as we pointed out in the example of photographing the man at different distances. Mr. Alfred Watkins gives the following table which compensates for the alteration of the *f* value of the stop:

Lanternslide making	Thin neg.	Med. neg.	Dense neg.
Copying	Black and white	Photograph	Colored object
15 times focus from lens.......	$\frac{1}{4}$	$\frac{1}{2}$	1
10 " "	$\frac{1}{4}$	$\frac{5}{8}$	$1\frac{1}{4}$
$5\frac{1}{2}$ " "	$\frac{3}{8}$	$\frac{3}{4}$	$1\frac{1}{2}$
$3\frac{1}{2}$ " "	$\frac{1}{2}$	1	2
$2\frac{3}{4}$ " "	$\frac{5}{8}$	$1\frac{1}{4}$	$2\frac{1}{2}$
$2\frac{1}{2}$ " "	$\frac{3}{4}$	$1\frac{1}{2}$	3
2 " " .... (copying equal size)	1	2	4

The numbers in the table are multipliers of the calculated exposure and not table factors to be added in determining it.

Example. — You are copying a photograph and find after focusing that the picture is $3\frac{1}{2}$ times the focus of the lens distant by measuring from lens to picture and dividing the distance by the focus of the lens. In this case the copying factor is 1 and the exposure is given as calculated. Suppose you wish a larger image and find, after focusing, that the focus of the lens is contained in the distance from picture to lens only $2\frac{1}{2}$ times. The copying factor is now $1\frac{1}{2}$ and the time given must be 50 per cent more than the first negative received.

Mr. Watkins also gives a similar table for enlarging. The numbers of diameters of enlargement are found by dividing the length of one side of the enlarged image by the length of the same side of the original negative.

Enlarging diameters.	Thin neg.	Med. neg.	Dense neg.
Equal size	1	2	4
$1\frac{1}{2}$	$1\frac{1}{2}$	3	6
2	$2\frac{1}{4}$	$4\frac{1}{2}$	9
$2\frac{1}{2}$	3	6	12
3	4	8	16
4	$6\frac{1}{4}$	$12\frac{1}{2}$	25
5	9	18	36

Example. — It is found that a thin negative requires 30 seconds when projected equal size. How much time is needed to make a four-diameter enlargement, all other factors remaining the same? Multiply 30 by the enlarging factor of $6\frac{1}{4}$ found under "thin negative" and opposite 4 diameters. The answer is 188 seconds, or 3 minutes, 8 seconds.

Other Systems of Stop Markings. — Some lensmakers mark their stops with variations from the standard English *f* system tabulated above, but the user can readily compare the values by squaring. In the same way, stops of fast lenses, such as *f*:3.8, 4.8, 5.5, 6, 6.3, 6.5, 6.8, 7, 7.7, etc., may be compared with the nearest regular *f* number and the percentage of increased speed noted. It may as well be said, however, that no shutter is accurate enough to make much difference as between *f*:7.7 and *f*:8, for instance. In the same way, *f*:6.8 is practically equivalent to *f*:7. If we consider *f*:8 as requiring an exposure of unity, the following fractions may prove useful in calculating the minimum exposure allowable for snapshots: *f*:8 = 1; *f*:7 = $\frac{3}{4}$; *f*:6.3 = $\frac{5}{8}$. For instance, if we have determined that 1–25 second is needed at *f*:8, at *f*:6.3 we could give 5–8 of 1–25, or 1–40 second, probably the marked 1–50 of our shutter. Another example: a portrait indoors might require 8 seconds at *f*:8, but at *f*:6.3, 5 seconds would suffice.

Speeds of Air-Space and Cemented Lenses. — Occasionally confusion arises from the conflicting claims of lensmakers, some stating that air-space lenses lose light by reflection and are slower than their nominal *f* numbers would indicate; while makers of air-space objectives, *per contra*, assert that a similar loss is due to absorption by the thick glasses used by their rivals. Both are right, within limits; but the loss of light, in the most unfavorable cases, can hardly amount to 25 per cent, and this variation from a calculated exposure is negligible. Besides, the maker ordinarily allows for any small variations in marking his stops, so that the values found on any good lens and shutter may always be assumed to be accurate for practical purposes. All lenses marked, for instance, *f*:6.3, may be taken as having the same speed.

Exposure with a Single Combination. — Most R. R. lenses are symmetrical, that is, they are made up of two " landscape " or " single view " lenses each of a focal length approximately double that of the combination. The actual diameter of the stop opening remains the same whether the combinations are used together or separately, but its *f* value varies. Thus, if the diameter is 1 in. and the focus of the doublet (both combinations in place in the shutter) is 8 ins., the *f* value is *f*:8; but if the front lens is removed and the same stop of 1 in. is used with the rear lens of 16 inches' focus, its value becomes *f*:16. This is why the Tables direct, " When using rear combination of lens only, add 2." One can, of course, find the real *f* value of any stop by actual measurement, and then no addition is needed. Some makers furnish a shutter for " convertible " lenses with the stop values for the doublet and each of the single combinations marked on the scale. In other cases, doublets are made up of single combinations of dissimilar foci and the user is left to find for himself the proper ratios for his stop openings. Here it is best to make a scale for one's self by measuring the focal length of each combination from diaphragm to plate when focusing on a distant object and dividing the diameters for each marking, measured on a wedge-shaped strip of card, into the focus. The marked *f*:8, etc., can then be noted down as being really *f*:11, let us say, for the rear combination and really *f*:18, let us say, for the front combination, or whatever the figures may be.

Light. — The Tables recognize five variations in daylight from intense sunlight to very dull, each decrease in intensity representing a falling off of 50 per cent in actinic value of the light. Smaller percentages would have no measurable effect. "Intense sunlight" is characterized by crisp, dark shadows. "Bright" is midway between intense sunlight and "faint shadow cast by sun," and may be called cloudy-bright, intense sunlight generally implying few or no clouds in the sky. It is easy to judge these conditions by observing the shadows. "Dull" is the condition seen when the sun is quite obscured and objects cast no shadows. "Very dull" is a value met only when the sky is wholly covered with dark-colored clouds.

Month and Hour. — The actinic value of the light changes not only with the amount of water vapor present in the atmosphere, but also with the altitude of the sun, and this factor is cared for by the month and hour number. Inasmuch as the summer solstice occurs in June, the four summer months, from the middle of April through the middle of August, have about the same mean altitude of the sun and the values are about the same at the same hours. The Tables are most reliable during the middle hours of the day, for yellow or reddish light early or late in the day is almost impossible to gauge by the eye. When the sun is sinking rapidly, exposure changes very quickly in a few minutes, particularly if plain plates are used. With the modern orthochromatic films, the numbers will be found reasonably correct, but the operator cannot dispense with judgment and must rely on past experiences for exposures made before 7 A.M. and after 5 P.M.

Altitude. — Generally speaking, no shortening of exposure need be made for altitude above sea level, unless it exceeds 5000 feet, when three-quarters of the calculated exposure may be given. Over 10,000 ft., half the regular time would be sufficient.

Latitude. — The table already given is intended for use in the northern part of the United States, about 35 to 45 degrees north latitude. This belt includes Newberne, N. C., to Bangor, Memphis to St. Paul, and Santa Fé and Los Angeles to Salem, Ore. The following tables cover the settled portions of the world at intervals of about 10 degrees of latitude. The months for latitudes north of the equator are given at the top of the tables, while those for the southern hemisphere are below.

For 60° N. Southern Siberia, Southern Alaska, Northern Canada, Iceland, Norway, Sweden, and Northern Russia.

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		0	0	½	1	1½	2	3
11	1	0	½	1	1½	2	3	5
10	2	½	½	1	1½	2	4	6
9	3	½	1	1½	2	3	5	.....
8	4	1	1½	2	3	5	.....	.....
7	5	1½	2	3	5	.....	.....	.....
6	6	2	3	5	.....	.....	.....	.....
5	7	3	5	.....	.....	.....	.....	.....
4	8	5	.....	.....	.....	.....	.....	.....
		Dec.	Nov., Jan.	Oct., Feb.	Sept., Mar.	Aug., Apr.	July, May.	June.

For 53° *N. British Isles, Northern Germany, Southern Canada, Southern Russia.*

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		0	0	½	1	1½	2	3
11	1	0	0	½	1	2	3	4
10	2	0	0	½	1½	2½	4	5
9	3	½	½	1	2	3	5	7
8	4	1	1	1½	2½	5	.....	.....
7	5	1½	2	2½	5	.....	.....	.....
6	6	2	3	5	.....	.....	.....	.....
5	7	5	5	.....	.....	.....	.....	.....
4	8	6	.....	.....	.....	.....	.....	.....
		Dec.	Nov., Jan.	Oct., Feb.	Sept., Mar.	Aug., Apr.	July, May.	June.

For 40° *N. Northern United States, Armenia, Spain, Italy, Turkey, Japan, Greece, Pekin, and Central China.*

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		0	0	0	½	½	1	1
11	1	0	0	0	½	½	1	1
10	2	0	0	½	½	1	1½	1½
9	3	½	½	½	1	1	2	2
8	4	1	1	1	2	2	3	4
7	5	1	1½	3	4	5	5	5
6	6	2	3	4	.....	.....	.....	.....
5	7	5	.....	.....	.....	.....	.....	.....
		Dec.	Nov., Jan.	Oct., Feb.	Sept., Mar.	Aug., Apr.	July., May.	June.

For 40° *S. New South Wales, New Zealand, Argentina.*

For 30° N. Southern China, Southern United States, Northern Mexico, Northern Africa, Arabia, Persia, Northern India.

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		—½	0	0	0	0	½	1
11	1	0	0	0	0	0	½	1
10	2	0	0	0	0	½	1	1
9	3	0	0	½	½	1	1½	2
8	4	½	1	1½	1½	2	2½	3
7	5	1½	2	2½	3	4	5	.....
6	6	3	4	6	.....	.....	.....	.....
		Dec.	Nov., Jan.	Oct., Feb.	Sept., Mar.	Aug., Apr.	July, May.	June.

For 30° S. Southern Australia, Northern Argentina, Cape Colony, Uruguay.

For 23° N. India, Mexico, Southern Egypt, Central Arabia, Cuba, and Northern West Indies.

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		½	½	½	0	0	0	½
11	1	0	0	0	0	0	½	½
10	2	0	0	0	0	½	½	1
9	3	½	½	½	1	1	1	1½
8	4	1	1	1	1½	1½	2	2½
7	5	2	2	2½	3	3½	4	7
6	6	3	4	6	.....	.....	.....	.....
		Dec.	Nov., Jan.	Oct., Feb.	Sept., Mar.	Aug., Apr.	July, May.	June.

For 23° S. Northern Australia, Northern Chile, Bolivia, Madagascar, Rio Janeiro, Transvaal.

Tropics, 20° N. to 20° S. Northern Brazil, Canal Zone, Central Africa, Ceylon, Borneo, Sumatra, Pacific Islands.

A. M.	P. M.	June.	May, July.	Apr., Aug.	Mar., Sept.	Feb., Oct.	Jan., Nov.	Dec.
12		0	0	$-\frac{1}{2}$	$-\frac{1}{2}$	$-\frac{1}{2}$	0	0
11	1	0	0	0	0	0	0	0
10	2	0	0	0	0	0	0	0
9	3	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
8	4	$1\frac{1}{2}$	1	1	1	1	1	$1\frac{1}{2}$
7	5	3	3	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	3	3

Exposure by Length of Shadow. — A very ingenious method of determining exposure at any time when the sun is shining, irrespective of latitude, season, or time of day, is given by Gaston M. Alves in *Photo Miniature*, No. 54. This is by stepping one's own shadow. "A person usually steps in regular, natural step, about 40 per cent of his own height, and it is easy to compute mathematically the length of his shadow on level ground, at given altitudes of the sun. On reasonably level ground let the operator note the point where his shadow reaches. Then let him measure the distance to this point in his usual steps." The table below gives numbers which combine the factors for sunlight, hour, month, latitude, and longitude, and it is necessary only to add the proper numbers for the plate and stop used, to determine the number corresponding to the exposure by our system:

23 steps	15 steps	11 steps	7 steps	5 steps	3 steps	$1\frac{1}{2}$ steps
6	$5\frac{1}{2}$	5	$4\frac{1}{2}$	4	$3\frac{1}{2}$	3

Direction of the Lighting. — Ordinary photographic lighting outdoors is when the light comes from over the operator's shoulder, and the calculated exposures

Harold D. Lafayette

Fig. 18.—Exposure with Sun Ahead

will be found correct in most instances. Once in a while, however, one wishes a different effect and takes the picture more or less against the light. Here the shadows at once occupy a larger portion of the picture and accordingly require much better rendering. When the light is across the subject, that is, at right angles to the axis of the lens, an increase of 100 per cent, signified by adding 1, is needed to prevent the shadows from coming out unnaturally black and lacking in detail. Similarly, when the sun is on the axis of the lens, or directly ahead (the lens of course being shielded with the hat or the plateholder slide from its direct rays), the exposure has to be quadrupled, as indicated by the instruction to add 2. See Fig. 18.

Adjusting Exposure by Trial. — No system of exposure determination can be exactly fitted to the ideas of the user without a trial, owing to inaccuracy of shutter speeds and to some extent to the individual's notion of a perfectly-timed negative for the printing process in use. Generous rather than scant time, however, is always to be preferred, for a well-timed plate can always be made to yield a printable negative by judicious development. If the true gradation of the tones is registered on the sensitive film by adequate exposure, the contrast between the tones can be regulated by shorter or longer development. Thus, negatives intended for bromide enlarging or printing on gaslight papers must not be carried so far as those intended for P.O.P. or carbon. The ideally perfect negative is the one which will produce the kind of print wanted on the paper in use. It is therefore advisable for the user of these Tables to make a few test exposures in the following manner.

Select a landscape subject which seems to you exactly to fill the definition of average landscape with foreground; for example, a view with trees about 25 ft. from the lens and nothing but grass, with perhaps a path running towards the trees, nearer than that distance. See that the sun is shining over one shoulder, illuminating the subject so as to cast good shadows in the foliage, but none over the immediate foreground. Calculate the exposure with the values printed in the Tables for the particular film in use. Let us take the example already given; namely,

Average landscape	3
Stop *f*:11 (U.S. No. 8)	6
Intense sunlight	0
11 A.M. in July	0
Eastman Non-curling film	$1\frac{1}{2}$

The sum is $10\frac{1}{2}$ and the correct exposure is 1–40 second. The test may be made so as to check the speed of the shutter and the speed of the plate at the same time. Give exposures of 1–100, 1–50, and 1–25 at U. S. 8. Develop in the strip, by either the tank or the tray method, for the standard time. It will probably be found that the 1–100 is very slightly undertimed, the 1–50 about right and the 1–25 slightly full-timed. In this case, you could reasonably estimate the 1–100 as 1–60, the 1–50 as 1–40, and the 1–25 as 1–25. A shutter which gave an accurate 1–100 might demonstrate decided lack of detail in the deepest shadows, and an accurate 1–50 would be almost correct. Sometimes the 1–25 is extremely slow, not more than 1–12 or 1–10, and in this case the exposure made at this speed would be considerably more than necessary. Occasionally there is no appreciable difference between 1–25, 1–50, and 1–100.

With a single-speed shutter, one marked simply " I " for the snapshot, the speed is almost sure to be between 1–20 and 1–40, and may for all practical purposes be called 1–25. If such a shutter is fitted with a rapid rectilinear lens working up to U. S. 4, the trial may be made by using for successive exposures stops U. S. 4, 8, and 16, and choosing the best-printing negative. If a single meniscus achromatic lens is fitted, the *f* value of the largest stop must be found by measurement as previously directed. Suppose it to be *f*:14, value 6½, our sum then becomes 11, which indicates an exposure of 1–25, exactly the supposed speed of the shutter. If the film is undertimed, it may be that the shutter works quicker than 1–25; if overtimed, slower. In the second case it may be possible to use the next smaller stop without getting serious underexposure.

The user of the cheaper cameras with stops numbered from 1 to 4 can employ the Tables to determine whether the only snapshot he can give will prove successful. If the exposure indicated is 1–20 to 1–50, the regular snap with the largest stop will probably answer; if 1–75 to 1–150, the second (smaller) stop can be used; if less than 1–12, hopeless underexposure is certain, and the camera must be used on a tripod for bulb or time exposure. If the *f* values of the smaller stops are known, the exposures may be calculated in the regular manner, using the correct values for the actual stops.

On the other hand, if the speed of the shutter has been tested and found accurate as marked, slight overexposure may occur. In this case it may be possible to alter the speed number of the film, calling it 1 instead of 1½; or, if undertime occurs with a tested speed, it may be advisable to use 2 instead of 1½. These points must be worked out by the individual to suit his own ideas.

Short "Bulb" and "Time" Exposures. — The beginner equipped with a single-lens hand camera, with only one speed of snap, will realize from what has been said that his chances of successful pictures depend almost wholly on giving enough exposure. Outside of the limits worked out above, he will therefore fix the camera to a tripod and use smaller stops with "bulb" or "time" exposure. A few hints about speeds may be useful. 1-5 second is usually the quickest exposure obtainable by setting the shutter to "bulb" and pressing and releasing the rubber bulb as quickly as possible. 1-2 and 1 second are similarly obtained, counting "one" and "one-and-one" respectively. A little practice with the empty camera soon teaches the knack. There are many schemes of counting seconds. One of the best is to count, "one thous-and, two thous-and," etc., saying three syllables slowly in time with a watch. A half-second pendulum is very convenient. This is made by tying a small, heavy weight, such as a bullet painted white, to a string just short of 10 ins. long — that is, the complete pendulum is between 9½ and 10 ins. long. Seconds are counted at one end of the swing only. Cameras having no "bulb" setting may be operated on the "time" setting in about 1-4 or 1-3 second by opening and closing the shutter as quickly as possible.

One-tenth second is about the slowest exposure which will show no movement when the camera is held in the hand. Some gifted individuals assert that they can give 1-5, 1-2, or even 1 second without blur, but the writer believes their shutters work much faster than supposed. The ideal shutter for hand-camera work would be one having actual speeds of 1-10, 1-20, and 1-40, as these are the most generally useful. The single-speed shutter is by no means to be despised, because that one snap is a reasonably constant factor and exposure is accurately regulated by changing the stop.

Exposures by Artificial Light. — The modern red-sensitive ultra-rapid plates of class ½ are particularly suitable for making exposures by firelight, lamplight, and the various forms of incandescent lights, including the regular Mazda and the nitrogen-filled bulbs. The Cooper-Hewitt light is very fast for ordinary (blue-sensitive) plates. Many of the orthochromatic plates are very fast to Mazda light. In general, if two plates in daylight are ½ and 1, their speeds will be reversed in artificial light, unless the particular light used is very rich in red rays. Yellow light is not very actinic to the class ½ plates, slowing them to class 1. It raises the speed of an ortho plate 50 per cent.

It is hard to suggest exposures for trial, owing to the tremendous variations in working conditions. With an *f*:4.5 lens, a color-sensitive plate, a 250-watt Mazda, and proper reflectors, however, a portrait can be made in a few seconds at most. It is helpful to remember that the actinic strength of light varies as the square of the distance. For instance, if the exposure is known with the light 4 ft. from the subject and one wishes to compute the exposure for a distance of 8 ft., it is not twice but four times (the square of 2, the doubled distance).

As a basis for experiment, the following data may be of use: Subject 6 ft. from lens, and light (a 60-watt Mazda) also 6 ft. from subject, with ortho plate of class 1½ and stop *f*:8; white reflectors used; an exposure of about ½ to 1 minute should be tried. With two lamps, approximately half the exposure could be given. The best combination would be a 100-watt as the principal and a 60-watt as the secondary source of light. While there may be a little difficulty in determining the exposure by a given artificial light, once found it is known for good, except for slight changes due to deterioration of the lamps. Cooper-Hewitt and other electric studio lights are therefore economical of material, as well as available at all seasons.

Artificial-light Hints. — Frank W. Palmer, who has made a specialty of the use of Mazda lamps in portraiture and commercial photography, kindly furnishes the following data. Great care is necessary in the lighting and particularly in the arrangement of reflectors, to avoid harsh results. Dead shadows cannot be lightened by excessive exposure, but only by the proper use of reflected light to modify them.

Using a 100-watt Mazda about 5 ft. from the sitter, with white background and white reflector, stop *f*:6, and a Cramer Inst. Iso D. C. plate, 15 seconds was found sufficient. Another subject was made with a 40-watt lamp shaded by one sheet of white tissue paper and placed 2½ ft. from the head, white reflector used on the shadow side, and an exposure of 1½ seconds given at *f*:5.5 on the same plate. Both were fairly well timed, and, though thin, print well on soft D. O. P.

Flowers have given good results with a 60-watt lamp about 2 ft. above and 6 ins. in front of the group. A sheet of white cardboard was set slanting in front of the group to reflect the light up, and two sheets of light gray card were used at the sides. An exposure of 40 seconds at *f*:6.3 gave an excellent result.

For still-life studies, the light should be far enough away to insure an even glow of light over the entire group. For example, a group 2 ft. wide should have the light at least 4 ft. away from the nearest point, and the exposure in this case would be about 3 minutes with a 60-watt lamp shaded with one sheet of tissue paper to secure diffusion. The reflector should be managed so as just to bring out the outlines on the shadow side.

Flashlight Exposures. — The following data will prove of value when determining the amount of flash-powder to use for different distances.

Plate, class 1½ color-sensitive; stop, *f*:8; distances as follows:

6 feet	15 grains
12 feet	40 grains
24 feet	105 grains
36 feet	180 grains

If pure magnesium powder is used instead of the compound powder, take three times as much.

Real Moonlight Pictures. — When the moon is full and high in the sky an exposure of 30 minutes at *f*:8 on a class 1½ film or plate will give, on an open landscape, a picture which cannot be distinguished from a daylight exposure except that there are no cast shadows. This affords the possibility of getting full detail on the northern side of objects without overexposing eastern or western faces. This is sometimes impossible by daylight. Such exposures, however, do not give the true moonlight effect, and about 20 minutes should seldom be exceeded. The disc of the moon itself may be registered in ½ second; and, as it moves rapidly, will show as an ellipse if given more than 2 seconds.

Shutter Speeds for Moving Objects. — These figures do not indicate the correct exposure for the plate, but simply the slowest speed which will give a sharp image. Object distance 25 ft. from lens of 5-in. focus and moving diagonally.

	Seconds
People walking in street scenes	1–10
Animals and people walking slowly	1–25
People walking three miles per hour	1–50
People walking four miles per hour	1–100
Vehicles at eight miles per hour	1–150
Vehicles at ten miles per hour	1–200
Vehicles at twelve miles per hour	1–250
Bicycle and horse races	1–500
High diving	1–600
Automobile and fast horse races	1–1000

If the object is 50 ft. distant, twice as much exposure can be given; and at 100 ft., four times as much. The longer the focus of the lens, the shorter must be the exposure.

Photographing from Moving Trains. — Many amateurs like to take pictures from the observation platform of a train. This kind of photography is the reverse of ordinary speed work, but the same principles apply. Regardless of the proper exposure for the shadows, one must use a shutter speed high enough to prevent blur. For pictures directly in the rear, an ordinary shutter will answer. The focal-plane shutter is efficient for angles up to 45 degrees, but it cannot secure pictures at right angles without distortion, if the train is moving fast. Between-lens shutters working at 1–250 are capable of making good pictures.

Night Photography. — Exposures suggested for trial at *f*:8, with ortho plates of speed $1\frac{1}{2}$:

	Minutes
Lighted show windows	1
Illuminated buildings	2
Open streets with arc lamps	3
The same, with wet roadway or snow	2
Close street scenes	6
The same, with wet roadway or snow	4

Exposures for Interiors. — Cover the camera and head with an opaque cloth and wait until the eyes are fully accustomed to the dull light. Stop down until detail can barely be seen in the deepest shadow in which you wish to render full detail. Note the stop and consult the following table for the exposure at *f*:16 of a plate or film classed as $1\frac{1}{2}$:

Stop noted	Exposure at *f*:16.
f:8	56 minutes.
f:11	28 minutes.
f:16	14 minutes.
f:22	7 minutes.
f:32	$3\frac{1}{2}$ minutes.
f:45	$1\frac{3}{4}$ minutes.
f:64	52 seconds.

For other stops or plates, calculate from the known speeds, remembering that each step in plate-speed factors represents 50 per cent, whereas each listed stop represents 100 per cent variation.

Summary. — The Tables, when once checked by test, are remarkably reliable as an indicator of the correct exposure. Variations from them may be made if the experience and judgment of the user dictate. Like everything else, they work best when used intelligently. When they fail, it is because no tables can accurately point out the precise actinic strength of the light at the moment of exposure. The only thing which can do this is an actinometer.

Exposure-Meters. — The actinometer exposure-meter is the one instrument which accurately measures the strength of the light falling upon the subject. The user of this device is not obliged to pay much attention to classification of subject, as he did in the case of the Tables. The meter is the invention of Mr. Alfred

Watkins, and we cannot do better than quote from *The Watkins Manual* what he says on this topic.

"If the unobscured sun rays always fell on the subject to be photographed, a simple exposure table would be a complete guide to the variation of light. But the altitude of the sun is only *one* influence affecting daylight, there being two classes of obstructions which interfere with the light falling upon the subject. These are: first, Clouds and Atmosphere; second, Physical Obstructions.

"**Clouds and Atmosphere.** — Clouds between the sun and the earth obstruct light, and that in proportion to the density of the clouds; hence we speak of the day being dull or very dull. But clouds also act as reflectors, and on many days when the sun is obstructed, they are thus secondary sources of light. Probably the most brilliant days in summer are those in which the sun shines at intervals between white fleecy clouds, and an object receives both the unobstructed sun rays and also light reflected by white clouds from every part of the dome of the sky.

"At times vapor or fog in the atmosphere greatly alters the color of the light and lessens its chemical or photographic force. Such a change is difficult to detect by eye, which can estimate only brightness and not chemical or, as it is called, actinic force.

"**Physical Obstructions.** — An object set out in an open plain with the whole dome of sky illuminating it receives the maximum amount of light. Anything in the way of trees, buildings, roof, wall, or mountain which cuts off any part of the sky reduces the light and tends to increase the exposure required. This is a far more important influence than might be supposed.

Let us suppose a wall is built on one side of the subject, and almost half of the light is obstructed. (We are presuming that the sun is not shining.)

"Let another wall be built on the other side of the subject, which is now illuminated only by a narrow strip of sky, and the light proportionately lessened. This explains why instantaneous work in streets is not always so successful as in open country.

"Now presume that a roof has been built over the walls, and the only illumination reaching the subject comes through a window. The volume of light is now enormously lessened, and to secure a correct exposure probably two or three hundred times the exposure must be given for that required under the conditions of the first example.

"It will now be seen why views under trees, near buildings, on porches and indoors require much longer exposures than open landscapes. . . . Fortunately, a test with a simple instrument called an actinometer will accurately give the value of the *light which falls upon the subject*, and *one* test will allow for month, time of day, clouds and atmosphere, and physical obstructions caused by the variation of subject. The actinometer (or exposure-meter, as it is called when combined with scales) has a disc of paper which is sensitive to the same kind of light as the sensitive plate. This paper darkens alongside a painted standard tint, and it is found by experience that the time required for darkening to the standard tint indicates accurately the photographic power of the light illuminating the subject. . . . There are many reasons why a simple actinometer test is more reliable than judging the value of the light by the eye. One is that light which has a yellow tinge (as towards sunset or in fog or east winds) may appear *visually* bright, but is *actinically* (or chemically) feeble. Another reason is that the pupil of the eye automatically accommodates itself to different degrees of light. We pass from the open air into a room which we call well lighted, and the eye does not give much information as to the enormous difference between the light in and out of doors; probably one to one hundred. The actinometer will give it with fair accuracy.

"In my system of exposure, therefore (which was original when introduced by me, although copied since), the keynote to the whole plan, and the golden rule is to

"**Test the Light which Falls upon the Subject,** and this rule applies to practically all cases in which a camera is used, and even for copying, enlarging, and photomicrographs where a condenser is not used. The standard for the actinometer is that it darkens to its standard tint in *best light* (that is, unclouded mid-day summer sunshine in England) in two seconds, and the darkening time in less active light will be in direct proportion to the altered time of exposure required. . . . It will be seen, therefore, that this *one* test with the actinometer fully allows for *all* the variations which the exposure-tables classify as month, time of year, time of day, state of atmosphere and (to a great extent) subject."

Exposure-Meters. — The two standard meters are the Watkins Bee Meter and the Wynne Infallible. Both are made in watch form and supplied for use with either *f* or Uniform System (U. S.) stops.

The Watkins meter is cheaper and has only one series of plate-speed numbers; the Wynne costs more and uses *f* numbers or U. S. numbers to denote the speed of the plates; the Watkins has a slower paper (or darker standard tint) and requires four times as long as the Wynne to make the actinometer test. In the Watkins instrument the stop number is set against the plate-speed number, and hence the scales do not have to be moved as long as the same stop is in use. The Wynne, on the contrary, requires resetting every time the light value changes, though the correct exposures for all the stops may be read as soon as the light value has been set against the plate speed number. Mr. Watkins' latest pattern, the Focal Plane meter, is arranged like the Wynne. It indicates half the exposure of the Bee pattern, as it is designed primarily for snapshots. The Wynne Snap Shot meter is similar. There is really very little to choose between them, as some workers prefer one and some the other. As, however, we have used the Watkins meter longer, we shall confine our remarks to our experience with it.

The first thing to learn in using a meter is to match the tint by its *darkness*, not by its color. That is, the paper must be exposed until it looks as deep a shade as the standard tint. A blue glass dial is a great help in preventing the tendency to match *color* instead of darkness. The length of time should be noted by the watch or by the swinging of a half-second pendulum.

The second thing is to select the correct plate number to use. Suppose you are using a film which is listed on the Watkins speed card as 90. Take the light value or actinometer time. Suppose it to be four seconds. Set *f*:8 (in column over "stop") against 90 (on the rim of the meter). Then against 4 (in column over "light") will be found 22, which means 1–22 second. Give 1–25 second at *f*:8 on an average landscape. Now calculate with plate numbers of 130 and 180, and give respectively 1–32 and 1–45 second. The best way to manage this is to use the same speed of the shutter and stop down to halfway between *f*:8 and *f*:11 for the 1–32 and to *f*:11 for the 1–45 second. When these exposures are developed together for the same length of time, it will be easy to pick out the one which gives the best print. Possibly an even higher plate number, as 250, might give passable exposure for snapshot work.

Using the Quarter Tint. — We have often found it more convenient to take the time it requires to darken the paper to the quarter tint, multiplying this by 2 to obtain the actinometer time for calculation, as we find the full meter time is rather more than is necessary, and our standard outdoor exposure is therefore *half* the Bee meter time, or exactly the Focal Plane meter time. In very good light, we use the darker, or standard tint, and calculate with *half* the number of seconds, which amounts to the same thing. The Watkins meters are now regularly furnished with only one tint, the standard. In using the Wynne meter, however, we find it difficult to judge the lighter tint, and use only the darker or standard tint, which requires by actual tests about the same time as the Watkins quarter tint. The first visible darkening of the paper in the Watkins meter takes place in one-sixteenth of the full actinometer time; hence this value may be used in dull light or indoors to shorten operations.

What Light to Test. — As a general rule, we find it advisable to counteract the tendency of the meter to indicate exposures which are unnecessarily great by testing the direct sunlight. The instructions (for Boston conditions outdoors, at any rate) should read:

Take sunlight for all average subjects. Where full detail is wanted in shadows *near the camera* in outdoor work, the meter should point to the sky in a direction at right angles to the sun's rays, which should not fall upon the paper.

For dark, heavy foregrounds, expose the paper in the shade of the body.

Always hold the meter to face the light which falls upon the subject, not to face the subject.

An Alternative Plan. — Lately, instead of using a higher plate number, we have been taking the published figures and using $\frac{1}{4}$ the time required for matching the full tint in calculating for snapshot exposures in hand camera work. We find that we thus get full exposure and a soft, quick-printing negative; but our shutter speeds are tested and the efficiency is high, as it is an expensive modern shutter.

These are really the only stumbling blocks which need to be removed in order to make the use of the meter easy and dependable. If you use a few films and thereby settle on a plate number which gives just the sort of negative you wish, there will be no chance of overexposure. The actinometer test is a strictly accurate measure of the actinic strength of the light. One afternoon in October at 3.10 P.M. we tested the light and got a full tint in sunlight in 8 seconds. Fifteen minutes later it took 45 seconds — nearly six times as slow, or the difference between exposures of 1–25 and 1–5. The eye could not distinguish any difference, but a plate given 1–25 would have been hopelessly undertimed at 3.25 P.M. No table could have measured this difference accurately. Hence the worker who aims at the best results from every exposure should learn to use a meter and fall back upon it when in doubt.

Prism Meters. — A form of exposure meter which is much liked by those who have become used to it is typified by the Heyde. In this instrument, blue-glass prisms are used to cut out the light reflected from the object. One looks through the eyepiece and turns the thicker portion of the prisms (one or both, according to the luminosity of the object) into position until the shadow details are suppressed. By reference to Tables, the necessary exposure may readily be found. Like all other devices of this nature, such an optical apparatus requires considerable adaptation to the user's personal equation, because the eye ordinarily can be made to accommodate sufficiently to accept as correct any one of a number of positions of the prisms, if viewed long enough. The user has therefore to try several positions in rapid succession until it becomes evident that a certain one does cut out the shadow details, whether compared to a lighter or to a darker portion. Once the knack is mastered, though, the user finds a Heyde meter very reliable and rapid in action.

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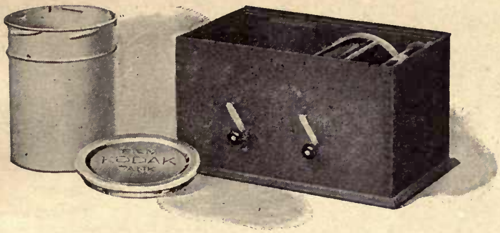

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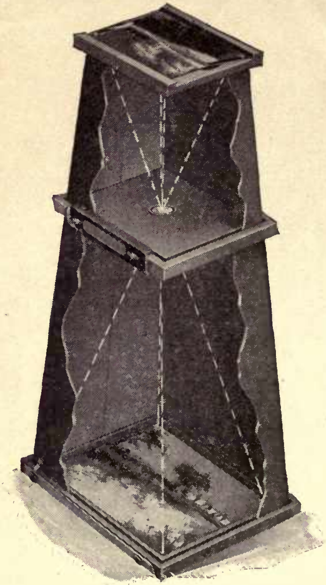

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