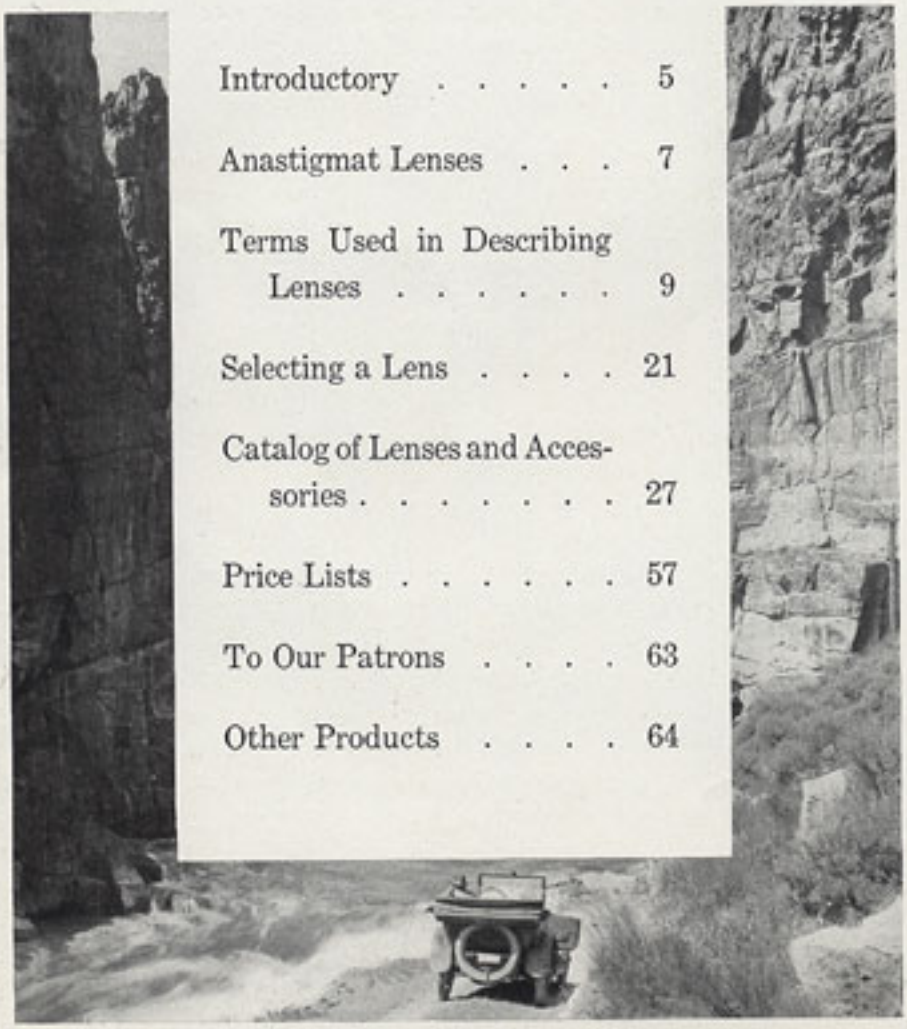
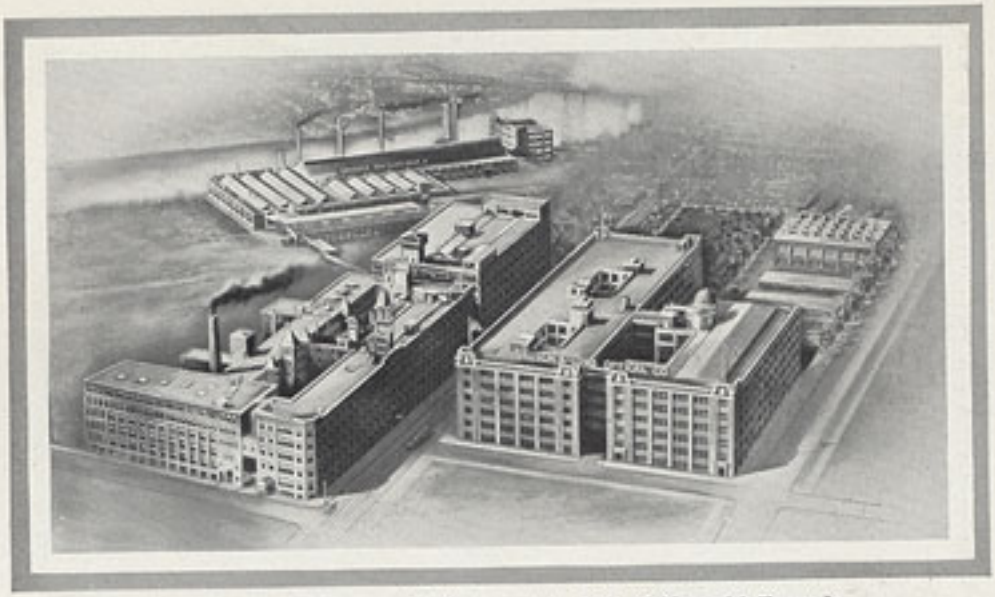
Photographic Lenses

BAUSCH & LOMB OPTICAL COMPANY

Capitol at Night

CONTENTS





Bausch & Lomb Plant—Aerial Photograph by J. G. McNett with Tessar Ic

INTRODUCTORY

BACK of the products presented herein lies a heritage of nearly seventy years of optical research and manufacturing experience, of which more than forty years have seen us in the photographic field. Devoted to optical endeavor of varied forms since the establishment of our business in 1853, we naturally became a pioneer agency in the development and popularizing of photography in America.

It was in 1878 that we produced our first photographic lenses, although they were only of the simplest form designed for small cameras. Our manufacture of double-system, or so-called Rapid Rectilinear lenses, was begun in 1885 and marked the approximate beginning of our serious endeavor along this line.

Prior to that time most of the photographic lenses used in this country were of European manufacture and high in price. The problem confronting us, then, was to equal the quality of the foreign product, at the same time reducing the cost to the user. How well we have met both counts of that issue is attested by the millions of our lenses which have since met every photographic requirement most successfully—on every type of camera, from the inexpensive vest pocket size to the modern aerial camera and the most elaborate professional equipment.

Our most significant contribution to American photography was the introduction of the Anastigmat lens in this country, shortly after its invention by the scientists of Carl Zeiss, Jena. This culminated in the production of the Tessar and Protar series, unexcelled representatives of that superior type, which it is our purpose to present in the following pages. The manner in which Anastigmats helped solve photography's most perplexing problems is indicated in the next chapter.

Pioneers also in the development of optical glass manufacture in America, we now control our own supply of this basic raw material. It

is possible, therefore, for us to work out our glass problem in our own plant, in advance of our lens and instrument problems and in co-ordination with them—a condition of no slight advantage in manufacture of this exacting character.

The work of our Scientific Bureau is also of special significance in our photographic production. The formulae for our different lenses are computed by our own staff of scientists—the same scientists who compute the formulae for practically every type of lens, from that of pinhead size for use in our high-power microscope objectives, to large searchlight mirrors five feet or more in diameter. Furthermore, they supervise both production and testing, to insure the finished product meeting the standard set by their computations.

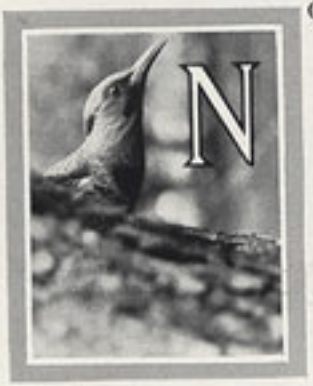
This new edition of our photographic catalog is the first to be issued since our department was released from its important wartime service. It purposes to afford brief information on the wide range of our products in this field. For those who may desire more complete or detailed information on lenses for portraiture, in studio or home, for photo-engraving, enlarging or any special work, we are always pleased to take up such questions by correspondence. Do not hesitate to refer your photographic problems to us. (For terms, etc., see page 63.)

Landscape Study

BAUSCH & LOMB OPTICAL COMPANY

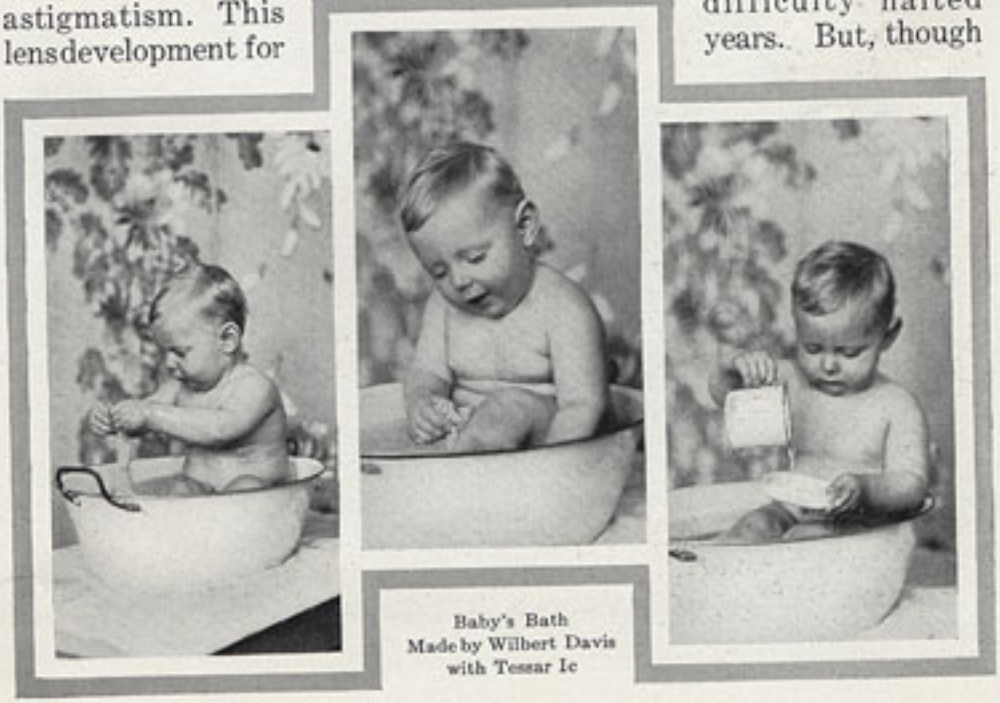
ANASTIGMAT LENSES

WHAT THEY HAVE MEANT TO PHOTOGRAPHY



O camera can give better results than its lens will permit; hence, the importance of lens manufacture to the enthusiastic photographer. In the early days of photography the lenses available were exceedingly slow and difficult to work with. Many experimenters, interested in the new science, tried to find a way to better them, but few met with any appreciable success. When faster lenses finally were invented, they had, from a modern viewpoint, a narrow field and other serious defects.

Numerous optical scientists undertook to produce a lens of greater versatility, which would overcome these defects, but it was more than twenty years before a lens was produced which represented a real forward step. This type, known as Rectilinear, was the first that proved its fitness to survive by combining spherical correction for a comparatively large aperture with freedom from distortion over a large field. Even this lens, which is still widely used in the simpler outfits, has one serious drawback, as it cannot be corrected for both astigmatism and curvature of field. If free from astigmatism, it has a curved field; or, if made to give a flat field, the margins show the blur of astigmatism. This lens development for the uncorrected difficulty halted years. But, though



Baby's Bath
Made by Wilbert Davis
with Tessar Ic

mathematics was baffled, science finally found a remedy—a *new glass.*

For this new glass modern optical science is indebted to the collaboration of Professor Abbe and Dr. Schott, of Jena. In 1881, Dr. Schott, at the suggestion of Professor Abbe, began his experimental effort to produce a glass with new optical properties. Up to this time the optical qualities of ordinary glass had changed in proportion to its specific gravity. The heavier the glass, the higher the refractive power and the greater the dispersive power.

Abbe, the mathematician, had advanced the theory that it was possible to produce glasses which, though they had refractive indices as high as heavy flint glass, should show no more dispersion than ordinary crown glass. Dr. Schott worked to produce such a glass, and after three years was so successful that a plant making this new glass was put into regular operation. It was glass manufacture of this character which we successfully developed during the European War and which we are now carrying on in our own plant at Rochester, N. Y.

The first man to utilize the possibilities of the new glasses for the purpose of photography was Dr. P. Rudolph, of Jena, who in 1890, made the first anastigmat. This lens had astigmatic correction over a large flat field and at the same time spherical correction for a large opening, covering a large plate well and with a short exposure. The first lens of this type was a "universal," with a moderate speed and angle of view. There soon followed lenses of higher speed, as well as wide angle lenses, and in 1895 came the Convertible Protar Series VIIa, which has since become famed for its wide range of efficient usefulness.

Anastigmat lens superiority over Rectilinear was immediately recognized and gave a great stimulus to lens construction. Every manufacturer sought persistently to acquire greater speed without sacrificing the field of view. All other efforts in this direction were finally surpassed by Dr. Rudolph in 1903, when he invented the Tessar type, which is unequalled in its perfection by any other lens.

As indicated in our introductory statement, we undertook the manufacture of both Protar and Tessar lenses in America shortly after their inception and have carried it on with increasing success ever since.

To summarize this chapter, the progress in lens optics during the last half century can be most vividly shown, perhaps, by a comparison between the old Petzval type of Portrait Lens and the present Tessar Ic.

Both lenses have the same speed, if the Portrait lens is diaphragmed down to F:4.5, and their brilliant images indicate perfect spherical correction. But, while one of these early lenses, as ordinarily used in a studio, will just about cover field enough to image the head and bust sharply and will do no more, even if stopped down, the Tessar, with full aperture, will cover a field more than twice as great, and, when stopped down, will take a group.

TERMS USED IN DESCRIBING LENSES

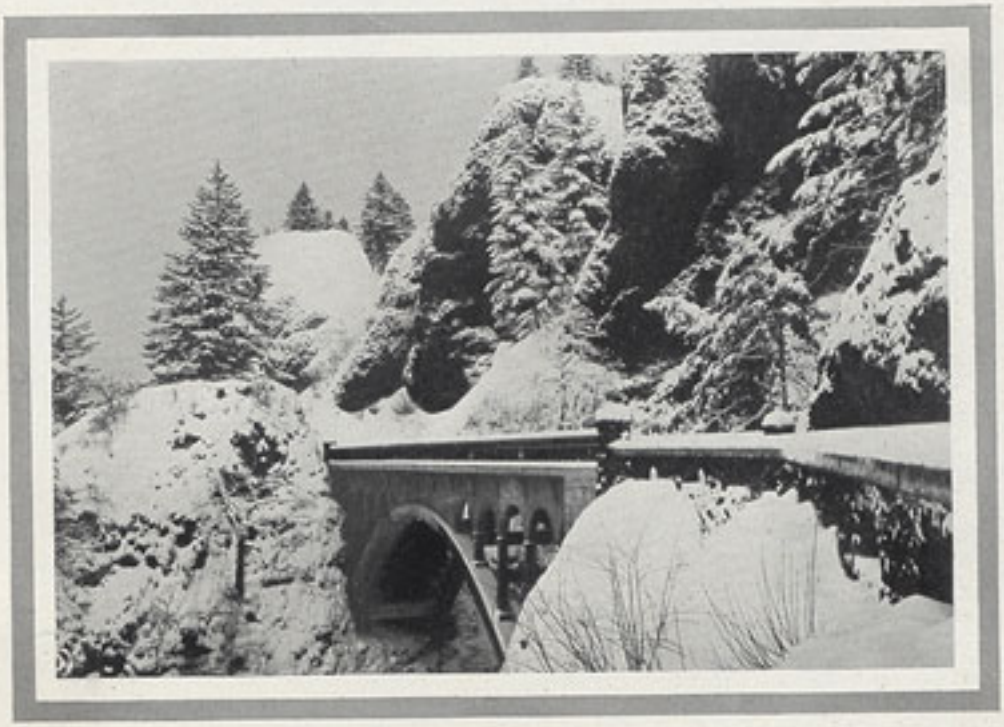
TECHNICAL terms used in photography are often puzzling to the amateur, particularly, perhaps, those terms which relate to the science of optics. The following glossary of optical terms has been prepared with a view to giving general information as to the descriptive words and phrases in ordinary use.

EQUIVALENT FOCAL LENGTH. **Focal Plane** is the plane in which a far distant object is imaged by the lens. The line drawn perpendicularly through the center of the lens is its Optical Axis; the point at which the Focal Plane intersects the Optical Axis, the Focal Point of the lens.

The **Focal Length** of a lens is the value upon which depends the size of the images produced by that lens. Its magnitude can be determined only by comparing the size of a given object with its image as formed by the lens. The distance of the object, unless very great, must also be considered.

For far distant objects the size of the image is in direct proportion to the focal length. A lens of 12-inch focal length will produce an image of a distant steeple twice as large as the image formed by a lens of 6-inch focal length.

Back Focus is the distance from the focal point to the rear surface of the lens. In the case of very thin lenses, this back focus is equal to the focal length, while in the case of lenses of considerable thickness and in combinations of lenses, the back focus cannot be relied upon as any indication



Columbia River Highway, Snowclad—Made by G. M. Davidson with Tessar IIb

Cloud Effects—Made by F. M. Locke with Tessar Ic and Ray Filter

of the value of the focal length. The focal length of such a lens is equal to the focal length of a thin lens, which gives an image equivalent in size to the one formed by the combination lens, hence the term **"Equivalent Focal Length."**

In the majority of photographic lenses the equivalent focal length is greater than the back focus, an exception being found in the Series VII, where the back focus is the longer.

By measuring back from the focal point a distance equal to the equivalent focal length, we find the position of the cardinal point of the lens.

ANGLE OF VIEW is the angle under which the diameter of the circular area covered sharply by the lens appears from the center of the lens (the point where the rays cross). If the largest plate, which the lens covers sharply, is used, the angle of view is equal to the angle under which the diagonal of the plate appears from the center of the lens. The angle of view **increases** with the **decrease** of the focus of the lens for the **same size plate.** Lenses for general purposes are calculated for an angle of about 60°. Lenses covering from 75° to over 100° are termed **Wide Angle Lenses.** Wide angle lenses have necessarily shorter foci than other lenses rated for the same plate. The diagram on page 55 enables one to determine the angle of view in any given case.

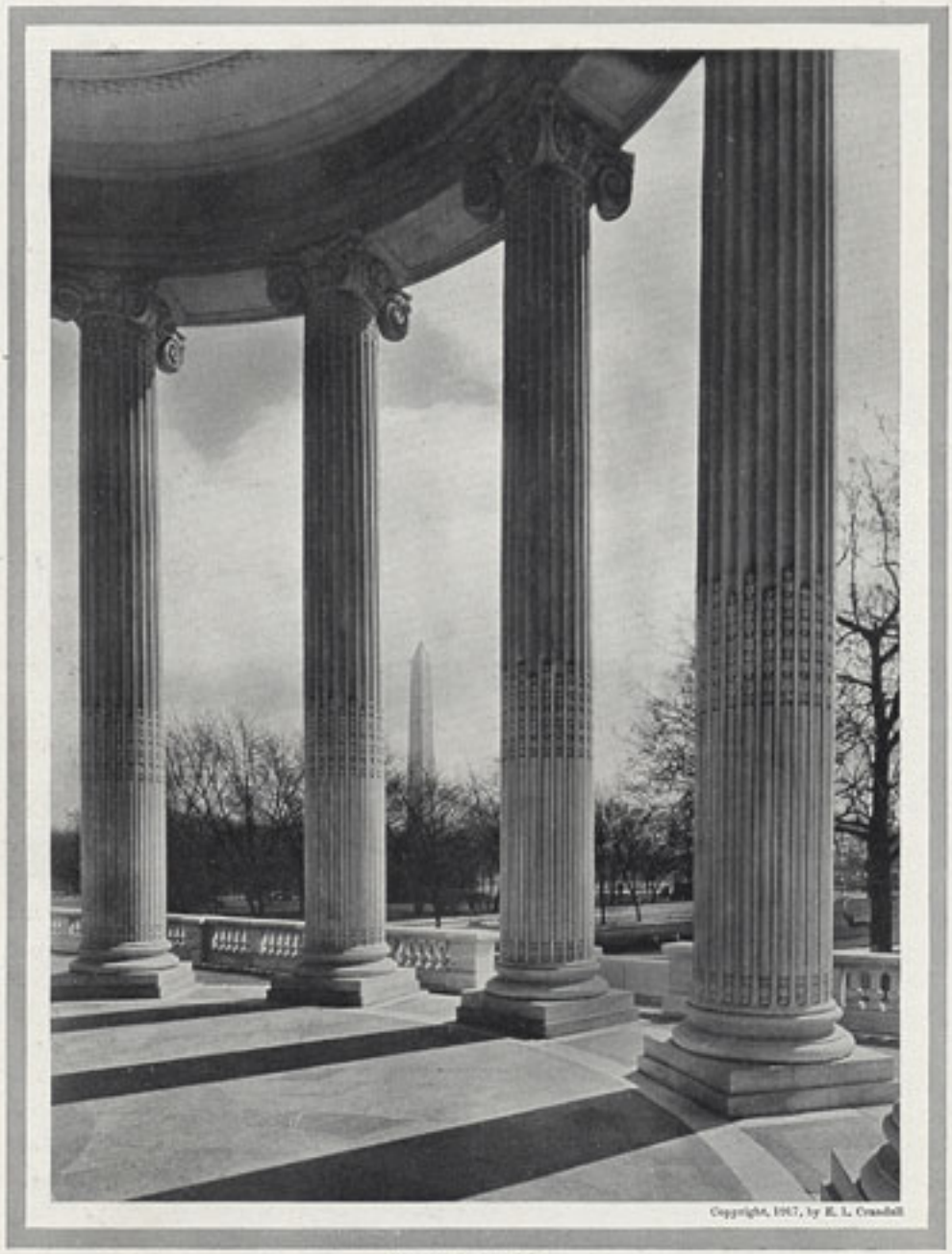
The circular area which is covered by the lens on the ground glass is called its **Image Circle,** and its diameter is expressed in linear measure (inches or centimeters).

Effective Aperture is measured by the diameter of the beam of light transmitted by the lens. The effective aperture is not, as often thought, equal to the diameter of the front lens, nor is it equal to the linear diameter of the diaphragm opening used. It equals the diameter of the diaphragm as it appears when observed through the front lens; therefore, the effective aperture cannot be found by unscrewing the front lens and measuring the actual diameter of the diaphragm. Only in the case of a landscape lens, like Series VII, where the diaphragm is placed in front of the lens, is the effective aperture expressed by the linear diameter of the diaphragm.

The effective aperture varies, of course, with the size of the diaphragm opening.

Relative Aperture is a fraction which expresses the ratio of effective aperture to focal length; for instance, relative aperture of 1:6.3 means that the focal length is 6.3 times greater than the effective aperture. The denominator of the fraction, in this instance the figure 6.3, is called the **F value.** If the relative aperture is known, the effective aperture can be found by multiplying the relative aperture by the focus. For example: F:160; relative aperture=1:8; effective aperture=160 x 1:8=20. The relative aperture is a term of greatest value and convenience in judging the

Park Scene—Made by Otto Stenzel



Through the Pillars

time of exposure. All lenses of the same relative aperture, no matter what their focus may be, require the same exposure under the same conditions. An exception will be mentioned under the heading, "Depth of Focus."

The exposures necessary for different relative apertures can easily be found because they are proportionate to the square of the F values. For instance, if two lenses are compared with the relative apertures of 1:4 and

1:8 respectively, the squares of the F values are 16 and 64 respectively, which means that the 1:8 requires four times as long exposure as the 1:4 lens, since $^{64}/_{16}=4$. This, of course, also holds true in comparing the different stops.

SPEED. The relative aperture is very commonly called the speed of the lens, although the speed of two lenses is not proportionate to their relative apertures but to their squares. In other words, a lens with the speed of 1:4 is not twice as fast as a lens with the speed of 1:8, but four times so, as the comparison of the squares of their relative apertures $1/16$ and $1/64$ shows.

There are two methods of designating lens stops, viz.: the so-called **F System** of the Royal Photographic Society, wherein the stop is expressed by fractions of the focal length, and the **U. S. (Uniform System)**, in which every following stop requires a doubling of the exposure or represents half the speed of the foregoing, the exposure required with F:4 being taken as the unit.

Comparison Between the F System and the U. S. (Uniform System) of Stops

F. System	F:4	F:4.5	F:5.6	F:6.3	F:7.7	F:8	F:9	F:10	F:11.3	F:12.5	F:16	F:22.6	F:25	F:32	F:45.25	F:50	F:64
U. S. . .	1	1.2	2	2.5	3.7	4	5	6.25	8	9.8	16	32	39	64	128	156	256

The above table gives the comparative stops in the two systems and shows at the same time the exposure values of the different stops in the F System. For instance, F:11.3 requires four times as long an exposure as F:5.6; and F:32, an exposure sixteen times longer than F:8, since $^{8}/_{2}=4$ and $^{64}/_{4}=16$.

DEPTH OF FOCUS. Very closely connected with the speed of a lens is its depth of focus. All well-corrected lenses image only one plane of the object space sharply. The reason why a lens focused at a house images also with sufficient sharpness, say a horse in front and a tree back of it, lies in the fact that a slight racking out of focus will not cause an indistinctness great enough to be noticeable to the eye. The range of sharpness forward and back of the object is called "depth of focus" or "depth of field." It depends on several factors, viz.: the focal length of the lens, the aperture used (consequently its speed), the distance of the object, and the amount of lack of sharpness which seems permissible to the operator. Of these factors, focal length, aperture and distance are definite numerical values. That the amount of indistinctness permissible in the picture is susceptible of numerical expression is easily seen from the following: if an object at a given distance is in sharp focus, the light issuing from a point of that object is converged to a point on the plate. Light issuing from a point forward or back of the object will also be converged to a point, but not on the plate, the cone of light showing in either case a circular patch on the plate. This circle of light is known as the "circle of confusion."

Facing a Climb—Made with Tessar Ic

Its diameter can be used to express the amount of indistinctness existing in a picture. If the circle of confusion is not greater than 1/10 mm or 1/250 inch, it would appear as a point to an eye 10 inches away, hence, an object no point of which is imaged by a circle larger than 1/10 mm would appear sharp.

No matter what their type of construction may be, **all lenses of the same equivalent focus and the same relative aperture require the same exposure,** that is, have the **same speed,** other conditions

being equal. They will also have the **same depth.** The depth of focus decreases:

1. With increase of focal length.
2. With increase of relative aperture (speed).
3. With increasing nearness of objects.

Of two lenses of the same equivalent focus, the one with the lower relative aperture (speed) has the greater depth of field. On the other hand:

Country Road near Boulder, Colo.—Made by T. C. Black, Jr., with Protar VIIa

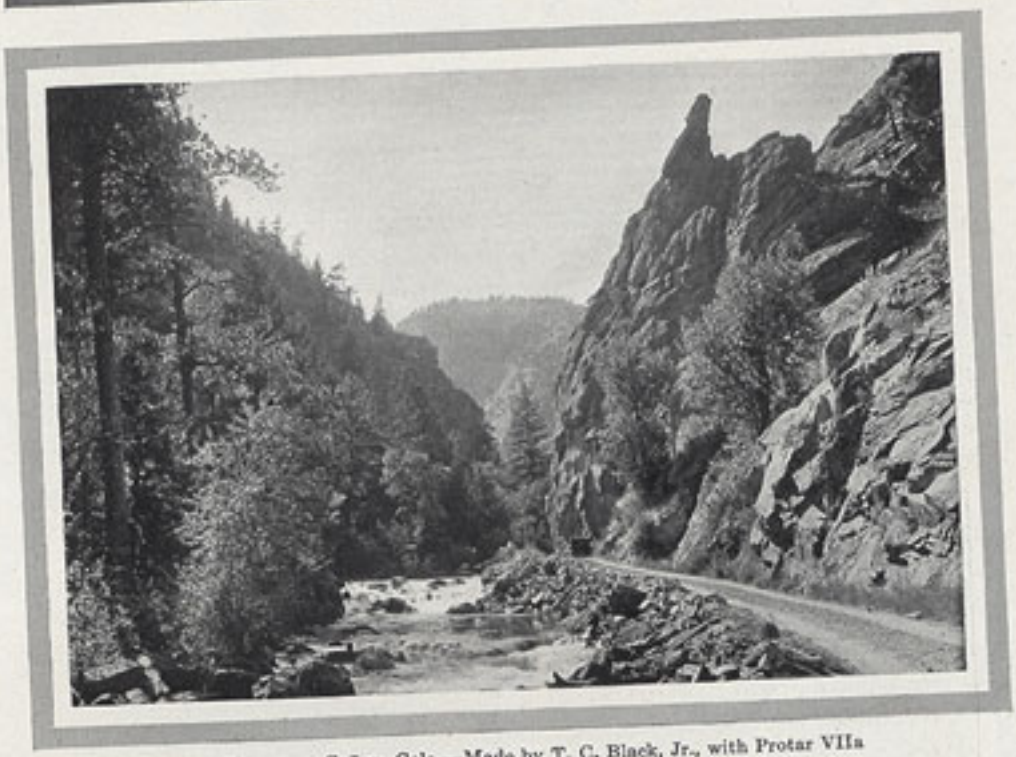
if the focal length of the lens is very short, a speed as high as F:4.5 will allow bringing every object from 10 feet to infinity to a sharp focus, while a studio lens of long focus and the same speed may not even image an object of the depth of a head sharply within the range of the length of a studio. Speed, great focal length and depth of focus cannot be combined in the same lens. **This is an unalterable law of optics.** If speed be the most desirable quality, depth of focus must be sacrificed; if depth of focus, speed. This does not detract from the value of fast lenses, because with a given lens the depth of focus can be increased by diaphragming down the lens which means reduction of speed. If a short exposure demands the use of the lens wide open, one must not expect great depth of focus. Under ordinary conditions of light and distance, with fair judgment, and with lenses not too long in focus, these opposing qualities may be happily combined, so that lack of depth is hardly perceptible.

Some apparent exceptions may be stated, for instance, a lens which

produces images of general "softness," i. e., a lens in which the aberrations are not corrected to the utmost perfection. Such lenses, which lack snap and brilliancy, may show greater depth of focus than a first-class lens. There is less difference between the "sharpest" focus and the image of objects forward and back of it, simply because the "sharpest" focus itself is not really sharp. Thus the statement that one lens has a greater depth of focus than others of the same aperture and focus, must be regarded as a rather doubtful compliment to the lens, for as stated above, **depth of focus cannot be made subject to special correction.**

Another case may be mentioned in which one lens may **really** have an advantage over another one, in regard to depth of focus. In some constructions, correction of astigmatism is obtained at a great sacrifice of simplicity by employing an unusual number of lenses separated by air spaces. There is a certain loss of light by reflection on a lens surface and it is easily intelligible that the fewer reflecting surfaces in a lens, the smaller the loss of light. In some constructions the number of the lens surfaces runs up as high as ten, while the Tessar contains only six. The consequence is that the lens with the greater number of reflecting surfaces requires a longer exposure than a lens of simple construction, although both may have the same relative aperture. Or to express it differently: the lens with the greater number of reflections requires an aperture of F:6.3 with a certain time of exposure, while the other lens will give a negative of equal density with its aperture stopped down to F:7.2 or F:7.5, which means a **gain in depth of focus** for the **lens** with the **smaller number of reflecting surfaces.** This is especially important with lenses used on folding cameras where the focusing is done without ground glass by means of a scale, and where the photographer has to depend on his unaided judgment and experience for getting the necessary depth of focus.

Spherical Aberration. Owing to the fact that lenses are made with spherical curves, all single collective lenses have the defect of imaging an object through their marginal zone at a shorter focus than through their central zone. Such a lens may give a sharp image with a small central diaphragm, and a sharp image as well if the center is covered with a round opaque stop so that only an annular zone around the margin comes into action. But both images will not lie in the same plane, nor will they be of the same size. Even if a lens is spherically corrected, so that the parallel rays penetrating the lens near the optical axis and those going through the lens near the margin come to exactly the same focus, there may be a slight remnant of spherical aberration in the zone between center and margin. Small remnants of this kind (so-called **Zonal Errors**) are found in almost all photographic lenses, especially of the cemented symmetrical type. The unsymmetrical combination upon which the Tessar construction is based, allows a better correction of the zonal errors than any other known construction. The greater the relative aperture (speed of the lens), the greater the task to correct the spherical aberration for all zones of the lens.



Big Thompson Cañon, Colo.—Made by T. C. Black, Jr., with Protar VIIa

Unsatisfactory spherical correction is indicated either by a general indistinctness of the image or by a fairly sharp image, which is entirely covered by halo (fog). Stopping down the aperture may improve the performance of a badly corrected objective.

Coma. The spherical aberration of pencils of light going through the lens in oblique direction is called **coma.** This manifests itself in the fact that although objects in the center of the field appear perfectly defined, objects outside of the center show a one-sided indistinctness which increases towards the margin of the field, and in the image of a point-shaped object assumes the form of a tail like a comet, wherefrom this aberration takes its name. Stopping down reduces the amount of coma.

Astigmatism. Astigmatism is that aberration which withstood longest the efforts of the opticians. A lens which is not corrected for astigmatism will not image sharply horizontal and vertical lines at the same time near the margin of the plate, although the center of the image may be perfect. This aberration is inherent in narrow pencils of light, so that stopping down the lens will not decrease the amount of astigmatism to the same degree that it decreases other uncorrected aberrations.

In the absence of a test chart a very simple test for astigmatism may be made by focusing on the joints of a brick wall. No matter how much the lens may be racked in or out, both horizontal and vertical lines will never be sharply defined at the same time near the margin of the plate.

CURVATURE OF FIELD. The ordinary lens images a flat object, not in a plane, but in a spheroidal surface, so that when the center of the image is focused sharp, the ground glass has to be brought nearer to the lens to obtain a sharp image of an object point near the margin of the plate.

Lenses which are free from spherical aberration for a large aperture and produce a flat image free from astigmatism, are called "Anastigmats," the prefix "an" meaning without, hence, without astigmatism.

DISTORTION is that fault of a lens which prevents the rendering of straight lines as such. The straight lines are reproduced as curves. All single lenses used with a diaphragm in front (landscape lenses) are subject to this defect in some degree. The distortion is called **cushion**

Class Rush beneath Flour Screen, University of Rochester—Made by A. R. Stone with Tessar Ic

shaped, when the curves are concave, and **barrel shaped,** when the curves are convex toward the margin of the plate.

Lenses which are free from distortion are called **rectilinear.**

The performance of a lens which distorts cannot be improved by using smaller stops.

Distortion has nothing to do with curvature of field. The image can be properly flat and the definition perfect, and yet straight lines may be distorted into curves.

CHROMATIC ABERRATION is due to the fact that in a lens, unless corrected for chromatic aberration, the visual rays which form the image seen on the ground glass do not form the images at the same position as the actinic or chemical rays, which affect the sensitive plate. Since the image is focused with rays for which the **eye** is most sensitive, the image formed by the rays for which the **plate** is most sensitive will fall outside of the visual focus (focal point), and therefore must be blurred on the plate. Of course all photographic lenses which claim to be of any value at all must, first of all, be corrected for chromatic aberration. An objective which has chromatic aberration is sometimes said to have chemical focus.

DEFINITION is that quality which enables a lens to produce sharp and crisp images, and its presence in an objective is a proof of exact workmanship as well as careful computation. The best workmanship will be wasted in a lens not well designed, and bad workmanship will annihilate the best computer's skill. If all the various defects and aberrations are corrected and the workman has done everything to carry out the designer's ideas, the lens will give at full aperture a flat and sharply cut image over the entire area covered. Among the few constructions which permit such perfection the Tessar type stands foremost. The area covered with perfection is sometimes called **area of critical definition.** Since most of the aberrations depend upon the opening of the lens, the definition may be improved in some cases by reducing the opening at the sacrifice of speed.

ILLUMINATION. We speak of even illumination when the margin of the plate receives as much light as the center, and the negative shows an even density all over. A perfectly even illumination is only possible with small stops, especially when a larger plate is used than the lens is rated for. All speed lenses show more or less drop in the illumination (vignetting) toward the margin of the field covered when used with full aperture.

COVERING POWER is expressed by the area which the evenly illuminated flat field covers with perfect definition. It depends upon the diameter of the lenses and on the degree to which the different aberrations are corrected and may, in some cases, be increased by using smaller stops.

The greater the relative aperture and the greater the covering power, the more valuable the lens.

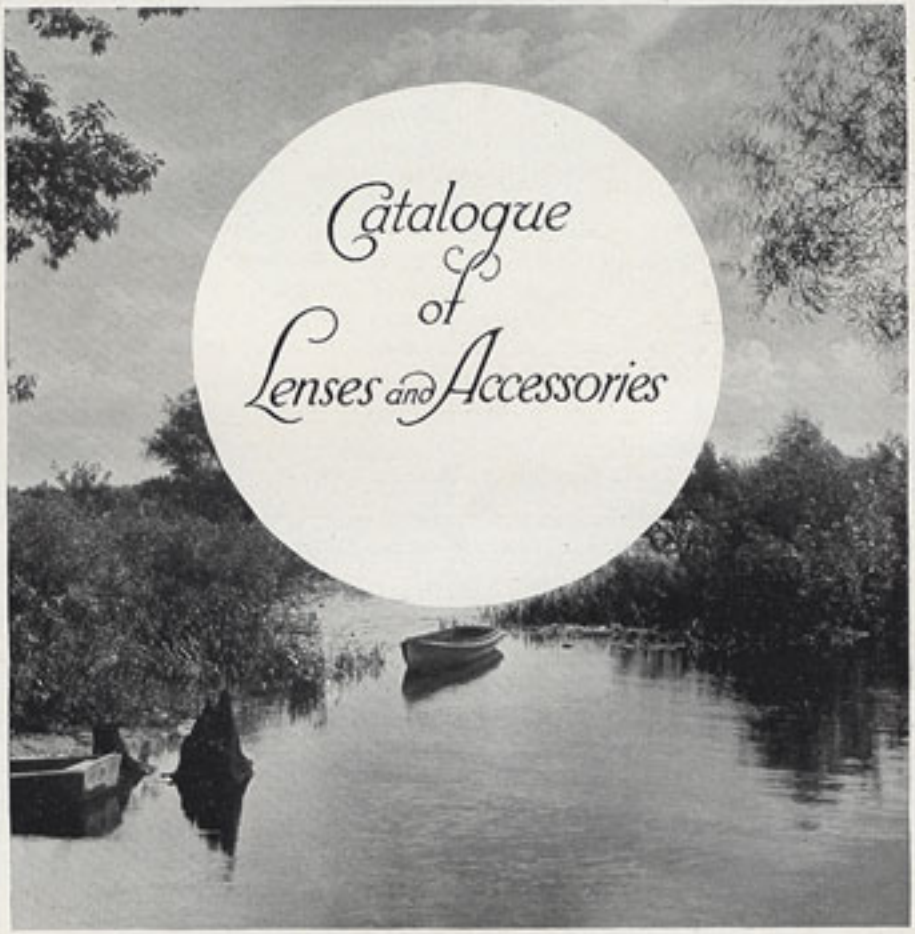
FLARE SPOTS. Occasionally a negative will show a nebulous patch of light covering shadows and highlights alike. Such patches are called **flare spots or ghosts.** They are formed by light reflected within the lens, at the lens surfaces bounding air spaces, and as a general proposition, it may be stated that every lens having an air space will show a flare spot under some conditions. Although it is possible to so adjust the curvature and direction of the lens surfaces that the flare spot is spread over nearly the whole plate, therefore, not noticeable, this generally could be accomplished only by sacrificing more important corrections.

Before it can be said that one lens is superior to another with respect to flare spot formation, the two lenses must be thoroughly tried out under a great variety of conditions of illumination. It will generally be found that if under certain conditions one lens shows a flare spot and another of different construction does not, by changing conditions the second lens will show a flare spot and the first will not.

Very small stops may show flare spots when larger stops do not.

Flare spots are most apt to appear when photographing an object against a strong light and least apt to appear when the light is coming from back of the camera.

"Everybody In!"—Seneca Park Lake, Rochester, N. Y.—Made by A. R. Stone with Tessar Ic



Catalogue of Lenses and Accessories

W. T. Tilden, Jr., in Action—Made by W. H. Zerbe with Tessar Ic

BAUSCH & LOMB TESSAR

Series Ic
F:4.5

Universal Application.

Actual Size

Unexcelled for ultra rapid work, portraits, groups, landscapes, etc.

THE Tessar Ic is admittedly the most universal lens of the unsymmetrical type. Its simple construction of thin glass elements makes the absorption of light practically nothing. The leading characteristic is speed. This aperture, F:4.5, is maintained in every size up to the largest, and its covering power in proportion to its focal length exceeds all other F:4.5 anastigmats. Combined with speed, we also have the highest optical corrections and needle-point definition.

The definition of the Tessar Ic at its full aperture, F:4.5, is remarkable. The lens will do all that it is possible to do with the Series IIb Tessar, and in addition has twice as much speed. This speed becomes available when the lens is opened up for short exposures at high speeds, or exposures when the light is very weak.

Tessar Ic is unequalled for the most difficult speed photography on reflecting cameras, for studio work, for home portraiture, groups, landscapes and other applications of the art. Compactness of mounting is an important factor in lenses for reflecting cameras, and the short barrel with inclined diaphragm ring, allowing easy reading of scale from front of camera, appeals to everyone. The lens is finished in black lacquer throughout.

The advantage of speed in a lens needs no argument. In the Tessar Ic it is available whenever you need it. At F:6.3 you have the same depth of focus and rapidity as the Tessar IIb, and so on through the smaller apertures. Tessar Ic should be put on all cameras which will accommodate its greater bulk, as it has twice the speed of the Tessar IIb and about four times the speed of the ordinary camera lenses.

The sizes No. 13 to No. 18 are recommended for reflecting cameras. Details are given on page 57 which cover all popular cameras.

Nos. 14 and 15 can be supplied also with **Sunk Mount,** required for use with some reflecting cameras. This should not be confused with the focusing style of mounting. It can be fitted to certain cameras usually provided with focal plane shutter, whose adjustable bellows extension folds into a very small, compact size. It has an adjustable diaphragm, actuated by turning the front combination mounting. See price list and specifications on page 57.

The professional will naturally select the No. 18a as an ideal lens for work in ordinary size studios, for cabinets, groups, etc. To cover the same size plate the older types of portrait lenses would require a much longer focus, which is a great inconvenience in group work. The Tessar Ic, with its perfectly flat field, makes possible groups and standing figures at large apertures. Special information on portraiture work with Tessar Ic is given on page 30.

For autochrome and other color-photographic processes, Tessar Ic gives superior results because of its high speed and perfect color corrections.

Ready for Trans-Atlantic Flight—Made by F. A. Korff with Tessar Ic

Tessar Ic can be used for difficult night photographs, for photographing windows at night, and is invaluable as a lens for enlarging from dense negatives where the lens must be worked at a large opening to save exposure time; or for enlarging work on the slower gaslight papers. See price list on page 57.

TESSAR Ic FOR STUDIO WORK

The larger sizes of the Tessar Ic are extremely popular for professional portraiture. They differ radically from the older types of portrait lenses, which could only cover when of inconveniently long focal lengths, owing to their limited central definition due to the greatly curved field. In the Tessar Ic, efficiency is the key-note—extreme covering power combined with the highest practical speed.

The flat field means ability to handle standing figures and groups at much larger apertures than the ordinary type of lenses. Exposures may be made with the Tessar Ic at much larger stops, which means less plates spoiled by possible movements of the subjects.

The reserve covering power of the lenses allows their use on larger size plates than regularly listed for, as in the case of groups. This reserve power is of great value also when the swing backs are used.

No. 18 lens is an ideal lens for home portraiture, and we have given information below in detail regarding this lens. For the ordinary studio with an 8 x 10 camera, the No. 18a with its longer focus is a better selection. No. 19 lens is excellent for large heads and for 11 x 14 work. No. 20 covers 14 x 17 and gives exquisite roundness and perspective.

The Tessar IIb is a less expensive lens than the Tessar Ic on account of its lower speed. The larger sizes, therefore, are in demand as group lenses and also serve for portrait work up to the limits of their speed.

Tessar Ic Nos. 18, 18a, 19 and 20 are supplied with lens hoods. These are detachable in case the lenses are to be used on compact home portrait cameras.

HOME PORTRAITURE

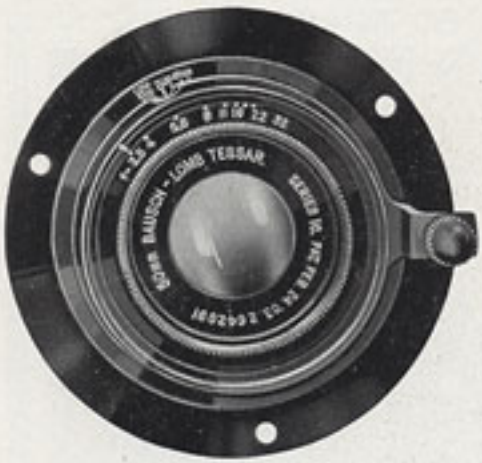
There is a steadily increasing demand for photographs made in the home, photographs with the home touch, the kind which show the favorite chair, the window seat with the little ones at play or the merry group on the stairway. These are the elements which add that subtle touch, so many times lacking in studio pictures, and make the negatives that sell.

In this class of work it is imperative that the lens have speed. At the same time it must be compact enough to go upon the lens boards of portable cameras. Efficiency, which is covering power combined with speed, is a necessity and the Bausch & Lomb Tessar Ic fills these ideal conditions especially in No. 18 size, listed for 8 x 10.

A lens for home portraiture should have a flat field, and the vignetting effect in the corners so common in the older types of lenses, which shows the inability of the lens to cover, cannot be tolerated in home portraiture.

Home Portrait—Made by Morrall Studios with Tessar Ic

In the home you must take conditions just as you find them. You will probably be hampered by lack of room. The No. 18 lens is about 12 inches in focus; it is short enough to work within the limits of space of the ordinary house and yet long enough in focus not to give the strained perspective of a lens too short in focus.



Actual Size

Series Ic, F:3.5

For Motion Picture Cameras of Any Make

The rise of the motion picture industry has brought up new problems, including a demand for lenses of enormous speed, as the motion picture operator cannot control the weather conditions and must usually take his pictures just as he finds them.

Owing to the short focal lengths which are ordinarily demanded, the speed of F:3.5 is attained. This means that the light admitted to the film is almost double that of the Series Ic Tessar, F:4.5, used on the reflecting cameras. Compared to ordinary camera lenses, Tessar Ic, F:3.5, is five times faster.

Owing to the short focal length of the lenses, 2 inch for the No. 1 and 3 inch for the No. 1a, the lenses have enormous depth even at fullest aperture. A greater speed than F:3.5, while attainable and useful on some occasions, shows a lack of depth qualities. F:3.5 represents the highest practical speed and it will be found that the lenses must be stopped down in good light, so as to prevent overexposure.

Lenses may be furnished in barrels with iris diaphragms, in focusing mounts illustrated above or in special mountings fitting a rack and pinion jacket. By revolving the lens hood, the diaphragm openings are changed and a pointer operating against a scale on the hood of the lens indicates the opening used. The lever on the side, pushes the lenses in or out, indicating the distance on the scale around the body of the mount.

In the rack and pinion mount, we have an ideal outfit for the man who wishes to use two or more lenses. The lenses set back in a double tube, the outer one fitting the jacket by a sliding fit and the inner one rotating so as to control the diaphragm. The mountings also serve as lens hoods, and the diaphragm settings can be read off on the outer end of the tubes.

For wide angle effects, the Tessar Ic, F:4.5, 32 mm (1¼ inches) focus, can be supplied. This lens is useful also for fixed focus work. It can be fitted to the focusing mount, if desired.

On the standard size film, No. 1a lens gives 20°, No. 1 lens gives 29° and the 32 mm Ic F:4.5 lens gives 44°. No. 1a lens will give a larger image from the same standpoint than the No. 1 or the 32 mm lenses.

For still larger images, an adapter tube carrying a No. 13, 15, 15a or 16 Tessar Ic can be furnished. The increase in image size is approximately in proportion to the focal length, a 15a Tessar Ic, 7½ inch focus, giving an image about three and three-quarter times bigger than 2 inch No. 1 lens.

See price list of lenses and adapters on page 57.

BAUSCH & LOMB OPTICAL COMPANY

BAUSCH & LOMB TESSAR

Series IIb
F:6.3

Actual Size

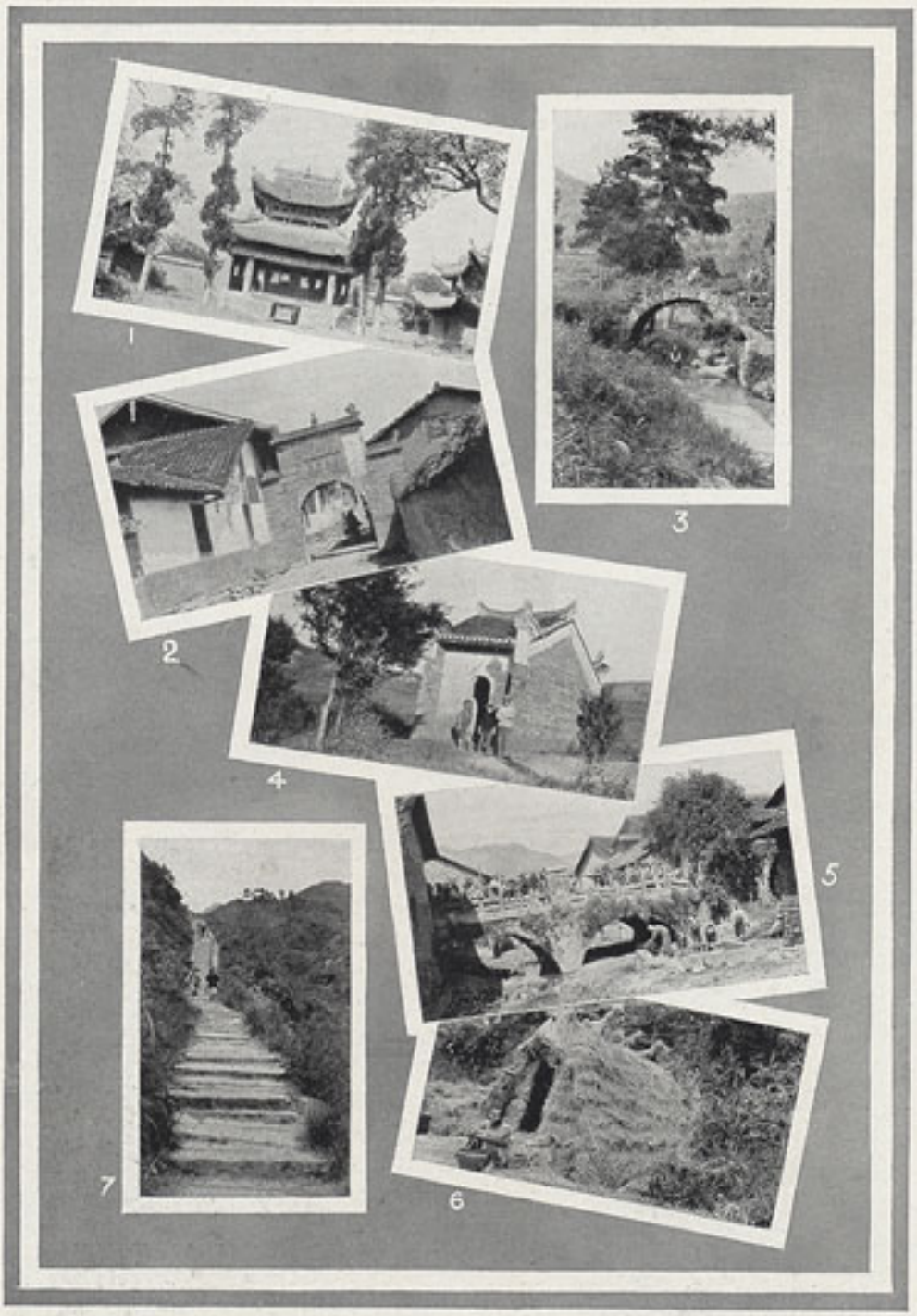
For general use on hand-cameras, groups, landscapes, commercial photography, enlargements, etc.

TESSAR IIb is one of the most compactly mounted and lightest lenses on the market, and can be fitted almost without exception to any compact hand camera on the market. It increases wonderfully the efficiency of any hand camera by making possible exposures on dull days, or late in the day, when ordinary lenses are completely out of commission. It has twice the speed of the ordinary camera lenses, and gives wonderful definition over the whole surface of the plate, way up into the corners.

The striking characteristic of Tessar IIb is the precision and sharpness of the image on the plate from center to margin, and hence it is especially recommended for use on small cameras where the negatives are to be subsequently enlarged. When stopped down, Tessar IIb increases in covering power. Its image circle is 60° when used at F:6.3 on plates for which it is listed, but on stopping down to F:32, the angle will increase to 66°, allowing its use on larger size plates as indicated by the tables.

"Lonesome Pine"
Made by J. Haberstroh,
with Tessar IIb

"Washington's Profile"
Made by Gen. C. C. Sniffen, U. S. A.
with Tessar IIb



Travel Views in China—Made by Rev. T. Kellar with Tessar IIb

1—Theater Stage in Court Yard of Main Temple, Nan Yoh; 2—Entrance to Main Street, Nan Yoh; 3—Bridge at Nan Yoh; 4—Wayside Shrine; 5—Village Well; 6—Blind Beggar and His Hut; 7—Foot of Ten-Mile Road up Sacred Mountain, Hunan

Its simple construction of four thin lenses gives practically no absorption.

For enlarging, Tessar IIb has special qualifications. Lenses intended primarily for enlarging can be specially corrected for this work.

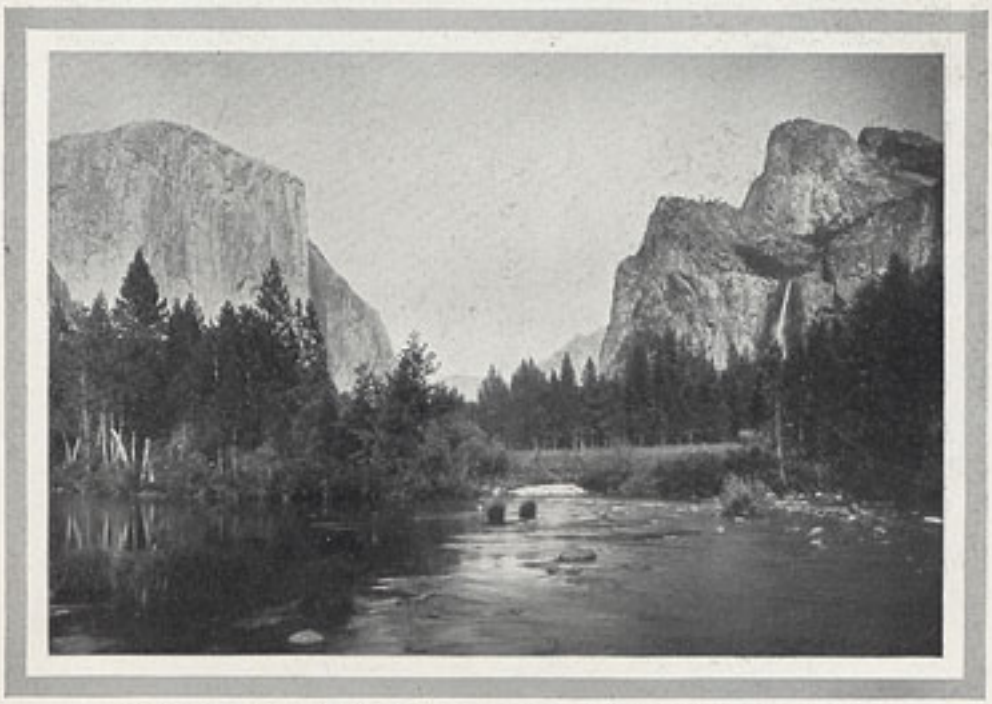
For home portraiture, the amateur will find the lens invaluable, as it will allow him to make seemingly impossible pictures of the baby in the house. For flash-lights Tessar IIb is also invaluable, as the focusing can be done with wide open lenses, an enormous advantage and convenience.

Tessar IIb is invaluable when a lens is desired for compact hand camera with short bellows extension, on which the advantages of a lens of several foci like the Protar VIIa cannot be utilized. Moreover, the simpler construction and hence, lower price of the Tessar, makes it preferable whenever the universal applicability of the Protar VIIa is not required. The smaller sizes, including 5a and 6 are generally selected, fitted with the Volute shutter.

For telephotography, Tessar IIb may be used in conjunction with our telephoto attachment, on account of its superb definition.

For copying and lantern-slide making the smaller numbers may be used by transfering them to cameras of suitable bellows extension, provided this is not available in the camera on which they are used.

The professional will find the larger numbers, from 8 x 10 upwards, to be invaluable for group work, exterior or interior. The advantage of a lens which will cover sharply with a moderately short focal length will be obvious to those who have been hampered by lack of room in making groups. See price lists and specifications of lenses on page 58.



Bridal Veil Meadow, Yosemite Valley—Made by B. M. DeCou with Protar VIIa

Old Mill, Busch's Gardens, Pasadena—Made by B. M. DeCou with Protar VIIa

BAUSCH & LOMB PROTAR

Series VIIa
F:6.3

Actual Size

A rapid, convertible lens, adapted for landscapes, architecture, portraits, groups, etc.

THE Series VIIa lens has satisfactorily solved the problem of variety and convenience; for composed as it is of two Series VII single Anastigmats, the doublet resulting from the combined components is simply perfection in all the qualities desired in a photographic lens.

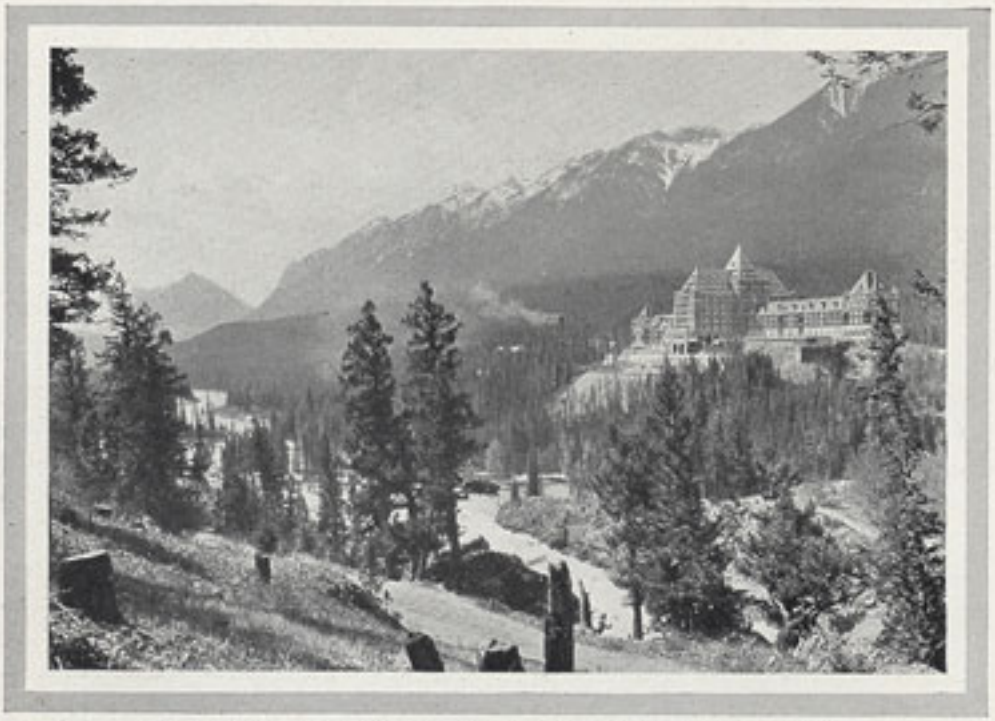
As single Anastigmats, the Series VII lenses have a distinct field of their own. They are perfect single lenses, having a speed of F:12.5, which is ample for instantaneous exposures out of doors under favorable light conditions. So perfect are the spherical and astigmatic corrections as to make the single lens almost equal to the doublet, and not only equal, but actually superior to many doublet lenses of other makes, for which strong claims to perfection are made. The field has an angle of 40° with full opening and with smaller stops 50°.

Series VII lenses may be used for a variety of purposes requiring long focus, medium speed and narrow angle, as, for instance, landscape work, commercial work, large portraits and groups. Naturally, they cover a smaller angle of view on the same size plate than the doublets of which they are a part, but they are, however, practically rectilinear.

For landscape work, they cover larger plates, as indicated in the tabular matter in the Series VII price list. They are excellent for distant objects, for this lens, like a telephoto, gives a large image at long range, and while its magnification is less than the telephoto, its speed is much greater.

Inasmuch as the component lenses can be used singly or together, it is evident that we have in the VIIa a **convertible lens**, which, as will be shown, is universal in application.

If in forming our Series VIIa doublet, we select two lenses of equal foci, we get a lens with a speed of F:6.3; if, however, we combine two unequal foci, there results a doublet with a speed of F:7 or F:7.7, according to the



Banff Hotel and Sulphur Range—Made by B. M. DeCou with Protar VIIa

relative foci employed. Thus, we have in one and the same lens one or two long focus single lenses adapted for a variety of work and an extra rapid doublet adapted for all kinds of instantaneous work. Although a doublet composed of two lenses of equal foci gives us a larger relative aperture and hence greater speed than one composed of two unequal foci, the latter has the advantage of being convertible into three lenses of different foci, where the former is convertible into two only.

While the single lenses (as has been stated) are adapted for instantaneous outdoor work when light conditions are favorable, for landscapes, portraits and groups, the doublet, if composed of two similar lenses, is an extra rapid lens working at a speed twice as great as the ordinary Rectilinear lens, hence is adapted for all kinds of instantaneous work, for groups, for architecture, and all subjects requiring medium angle, good covering power and brilliancy.

When stopped down, the available image circle covers an angle of from 85° to 90°. The doublet can therefore be used as a wide-angle lens on larger size plates, allowing focusing with plenty of illumination.

These lenses stand at the head of the list both in optical qualities and their adaptability to the limited space allowed for the lens. When the bellows draw is sufficient to enable the use of a long focus lens the VIIa is especially desirable, because it is not only a doublet of moderate focal length, but also one or two long focus single lenses according as the doublet is composed of lenses of equal or unequal foci. In selecting the lens one

must be sure that the back focus of no combination selected is longer than the greatest extension of which the bellows is capable.

To illustrate the facility with which sets of Convertible Protars may be made up and the uses to which they may be put, let us start with a Series VIIa doublet No. 8. This lens is listed to cover a 5 x 7 plate, has a focal length of 7 inches and a speed of F:7, which is almost twice as fast as the ordinary camera lens. It is composed of two perfectly corrected single Anastigmats Nos. 3 and 4 Series VII of 11 3/16 inches and 13¾ inches focus respectively, listed to cover 6½ x 8½ and 8 x 10 plates with an opening of F:12.5, which is sufficient for instantaneous work under normal light conditions. We have, in other words, three Anastigmat lenses in one—two single Anastigmats and a doublet. Now let us add to this equipment a No. 2 Series VII which covers a 5 x 7 plate and has a focal length of 8¾ inches. The addition of this forms the C set of Convertible Protars listed on page 59. We have now three single lenses which we may combine as follows: our original doublet of 7 inches focus; we can form a doublet with our 13¾ inches and 8¾ inches with a resulting length of 6⅛ inches covering a 4¼ x 6½ plate and a speed of F:7.7; or we can form one of 8¾ inches and 11 3/16 inches having 5⅝ inches focus, covering a 4¼ x 6½ plate and having a speed of F:7. In other words, we have three single Anastigmats and three doublets. The cost of these lenses is $131.00 or an average of $21.83 apiece. Is it possible to purchase any other perfect Anastigmat at so low a cost?

Washington's Tomb, Mt. Vernon—Made by A. Melzer with Protar VIIa

Multnomah Falls, Columbia River Highway—Made by B. M. DeCou with Protar VIIa

"Paradise Valley"—Made by A. R. Barnes with Protar VIIa

If we desire a faster lens we need only to match one of our single lenses to form a symmetrical doublet having a speed of F:6.3. The choice of lens is governed by the class of work to be done. This illustration demonstrates the enormous advantage of the Convertible Protars and proves their claim to convertibility, variety and usefulness. Other combinations may be formed by selecting such lenses of the Series VII as can be combined. The lenses which it is practicable to use together, are shown in the list on page 59.

To sum up the advantages of the Series VIIa lenses:

They are perfectly corrected as are all our Anastigmats.

Every doublet is in reality three lenses, each perfectly adapted for a different kind of work.

The addition of one system adds three lenses, making six in all.

The addition of two systems adds seven lenses, making ten in all.

The greatest possible compactness is secured.

The least weight.

The fewest parts to lose or wear out.

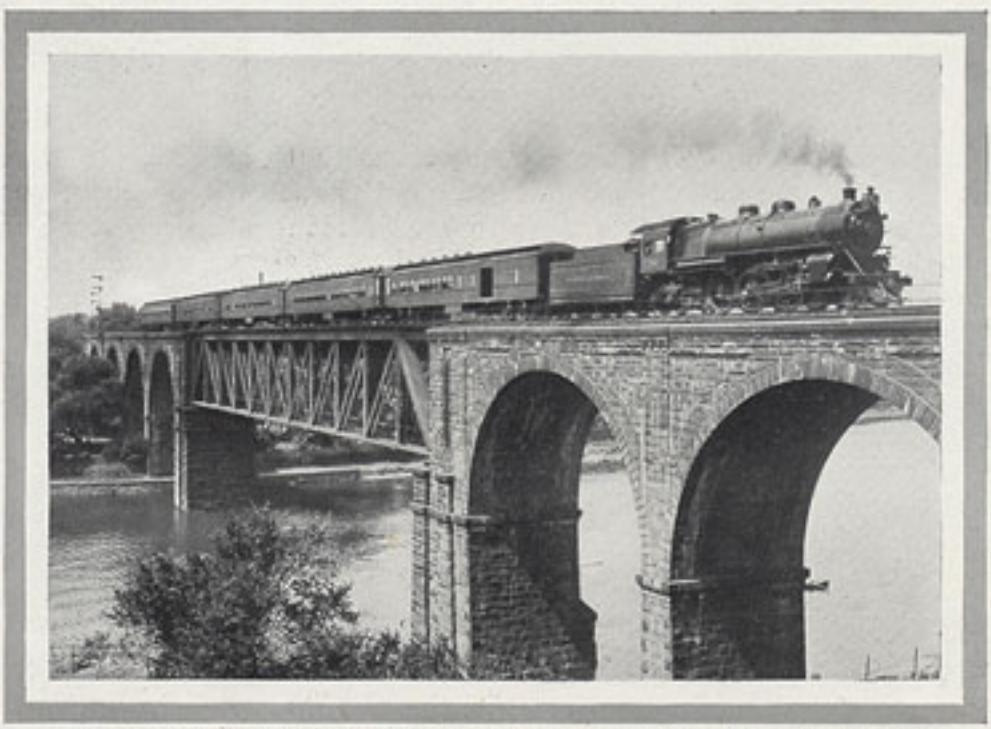
When two Series VII lenses of unequal foci are combined, the longer focus Series VII should be used in the front to obtain the largest possible aperture and hence, the greatest speed. See price list and specifications on pages 58 and 59.

BAUSCH & LOMB CONVERTIBLE PROTAR VII IN SETS

We list a large number of doublet combinations, and the purchase of additional Series VII combinations will furnish new focal lengths, thus increasing proportionately the usefulness of the lens.

We offer two sets complete with lenses mounted interchangeably, each set consisting of: one lens barrel with iris diaphragm, cap and flange, and set of screws, the single Protar lenses (three or four, as the case may be); a neat and compact leatherette case containing all the parts of the set, or including shutter if so ordered. A screen ring is also furnished to screw into front of barrel or shutter when single elements are being used. This furnishes a method of attaching a ray filter if desired.

The advantages of such sets are manifold. Every commercial photographer has a desire to own a set on account of their convenience. A lens for any purpose is instantly at hand. Many advanced amateurs are possessors of these sets which may be built up gradually if the entire investment cannot be made at once. See price lists and specifications of lenses on page 59.



Pennsylvania Bridge over Schuylkill River, Philadelphia—Made by J. B. Rich with Protar VIIa

Made with
Protar VIIa
No. 12, 9⅛-in. Focus

Made with
Protar VII, Back
Combination
13¾-in. Focus

Made with Protar VII, Front Combination
18¾-in. Focus

THE above series of three photographs of Memorial Chapel, St. Augustine, illustrate some of the different image size possibilities obtainable with Convertible Protar. The camera remained in the same position throughout the three exposures. Details of combinations are given under each picture.

BAUSCH & LOMB MEDIUM WIDE ANGLE

Series IV
F:12.5

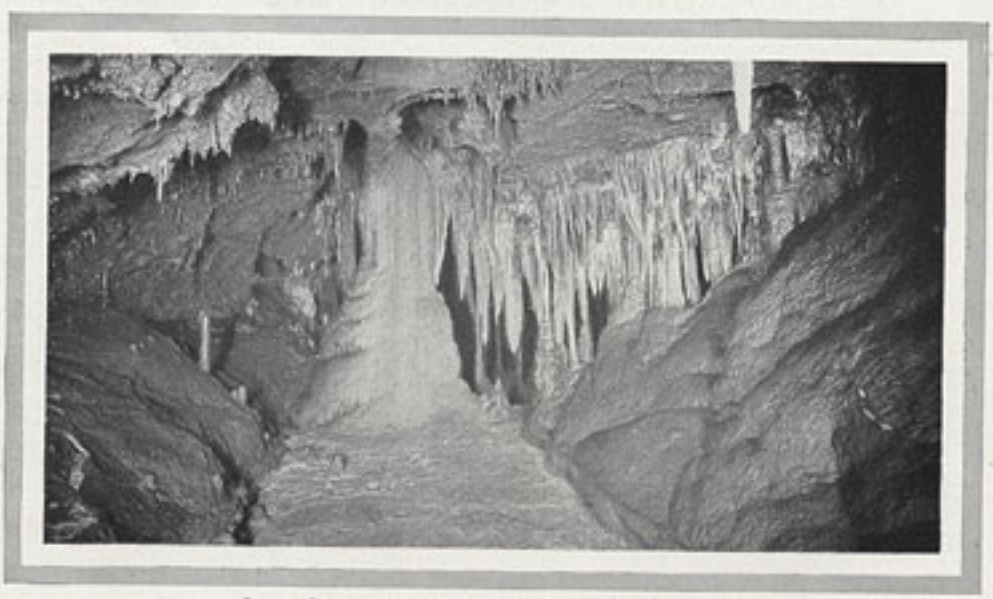
Actual Size

A rapid wide angle lens for architectural work, for flashlight interiors and groups

SERIES IV has two special points of merit—speed and covering power. It works at a speed of F:12.5, which is sufficient for instantaneous exposures out of doors, under favorable light conditions. Its large relative aperture makes it an admirable lens for flashlights of interiors and groups, admitting ample light for focusing interiors, and enabling one to obtain sufficient illumination with less flashlight than is possible with lenses of smaller aperture.

We recommend Nos. 1 to 6 inclusive for rapid, wide angle work, for example, architectural or other subjects to be photographed instantaneously, and where the distance of the object from the camera is such as to necessitate the use of a wide angle lens.

A Series IV lens of moderately short focus will cover a comparatively large plate. The volute shutter can be fitted easily to these lenses, but other shutters cannot be fitted on account of slight separation of elements. See price list and specifications of lenses on page 60.



Luray Cavern—Flashlight by A. Melzer with Protar V

BAUSCH & LOMB EXTREME WIDE ANGLE

Series V
F:18

Actual Size

For architectural and interior work requiring an extreme wide angle lens

THIS lens should be chosen for the most exacting wide angle photography, because the corrections for flatness of field and astigmatism have been carried to a greater degree of perfection than in other lenses of a similar type. Its effective angle and covering capacity especially recommend the Series V for architectural and interior reproductions.

Larger plates are well covered at smaller apertures with increased angle of view. The Series V is unsymmetrical, and the combinations cannot be used singly.

The speed F:18 is sufficient for outdoor instantaneous photography under favorable light conditions. We can easily fit the Series V lenses to our Volute shutters. These are of the diaphragm type and can easily go between the combinations, which in the series V are very close together.

In order to get the widest angle upon the Series V lenses we use a smaller size than listed for the plate we wish to cover. When this is done, the lens of course has to be stopped down somewhat to gain the extra covering power.

Series V lenses may be used for flashlights, copying, etc., and in fact for any work up to their limits of speed. The longer focus members are excellent for copying work. Prices on page 60.

Stalking Water Lilies — Ice Boating with a Thrill

Made by W. H. Zerbe with Tessar Ic

Interior—Made by Henry Fuermann with Protar V

BAUSCH & LOMB PROCESS ANASTIGMAT—F:10

Actual Size

THIS new lens, presented here for the first time, is corrected to meet the full requirements of the modern photo-engraver. While designed primarily for black and white work, its perfect register of colors permits it to be used most satisfactorily at the smaller apertures for three and even four colors. It is made after our own formula, entirely of our own glass, and, we believe, is the first process lens for color work to be produced in America.

For commercial photography, as enlarging and copying, this lens is also very satisfactory, giving critical definition throughout the field with all plates of the sizes listed. It can even be used with larger plates in such cases as do not require critical definition to the very corners.

Prisms for reversing the image, in order to save stripping the films, are made by us and can be fitted to any lens for process work. To ensure their accurate fitting the lenses should always be sent to us.

Ray filters for three-color processes must be made with the highest accuracy; otherwise the delicate corrections of the lenses would be disturbed and the register of images thrown off. We make the Precision Ray Filter, of highest possible quality for the finest grade of work, and will gladly quote prices upon request.

These and other sundries, including focusing and retouching glasses, are listed on page 62. For price list and specifications of the Bausch & Lomb Process Lens, see page 60.

TELEPHOTO ATTACHMENT

Two-Thirds Actual Size

A TELEPHOTO lens is a so-called negative element, that is, a dispersive lens, and it must be used in connection with a photographic objective, which is the positive element. It is always of shorter focal length than the positive. It magnifies the image produced by the latter, so that it forms a valuable adjunct to a photographic equipment, especially since it makes it possible to get pictures of views otherwise inaccessible by reason of distance or location.

The Telephoto affords a very wide range of focus with ordinary bellows extension, and gives the same good perspective as the long-focus lens with the same bellows extension.

Because of the magnification of its image by the Telephoto, the photographic lens should be as perfect as possible, for all defects will be magnified in exactly the same proportion as is the image. With the magnification of the image there is a decrease of illumination, because the same amount of light is distributed over a considerably larger area. Thus, the exposure must be longer and it is, therefore, highly desirable to use a fast lens for this class of work in order that the exposure may not be too prolonged.

U. S. Military Prison on Alcatraz Island, San Francisco Bay—Made by R. E. Merville with Protar VIIa, No. 8

Illustrating Construction of Telephoto Attachment

Again, the magnification has a direct bearing upon the size of the plate covered. With otherwise equal conditions as to equivalent focus, relative aperture, etc., as the magnification decreases, there will be a proportionate decrease in the area of the field, that is to say, with a higher magnification the plate will be more fully covered than with a lower one. This is due to the fact that in the lower magnification the mounting cuts off the marginal rays and thus prevents the plate from being fully covered.

Our Telephoto is thoroughly corrected for spherical and chromatic aberrations, so that with proper manipulation, good results are assured. The negative lens (Telephoto) is mounted in a tube adjustable by means of a spiral device. The tube is graduated to indicate the varying magnifications which can be obtained. The photographic objective screws into the front of the tube at the end opposite the Telephoto lens. We list Telephotos suitable for use with lenses of from 6 to 14 inches equivalent focus.

The time of exposure required for Telephoto combinations can be found by multiplying the time that would be required by the positive element alone by the square of the magnification used.

For instance: the exposure for No. 15 Tessar Ic with stop F:16 may be ½ second; with a magnification 3x, the exposure would have to be 9 times longer, i. e., 4½ seconds, and with a magnification 8x, an exposure of 64 x ½ = 32 seconds.

Positive Lens		Tele-photo	At Three Magnificat'n		At Eight Magnificat'n		Positive Lens		Tele-photo	At Three Magnificat'n		At Eight Magnificat'n	
Number	Equival't Focus Inches	Negative Elem't	Image Circle Inches	Bellows Draw Inches	Image Circle Inches	Bellows Draw Inches	Number	Equival't Focus Inches	Negative Elem't	Image Circle Inches	Bellows Draw Inches	Image Circle Inches	Bellows Draw Inches
15 Ic	6½	2	5¼	4⅝	16	16	10 VIIa	7⅞	3	5½	5⅛	17½	19⅞
15a Ic	7½	2	5	4⅝	14¼	16	11 VIIa	8½	3	5½	5⅛	16	20¼
5 IIb	6⅛	2	5	4⅝	15½	16¼	12 VIIa	9⅛	3	5¼	5⅛	15½	19¾
5a IIb	7⅛	2	4½	4⅝	13	16	13 VIIa	9¾	3	5½	5⅛	17¾	19¾
5k IIb	6¾	2	5	4⅝	13½	16	14 VIIa	10	3	5¼	5⅛	16	19⅝
6 VIIa	6⅛	2	4¼	4⅝	15	16¾	18 Ic	11¾	4	9	7¼	24	26⅛
7 VIIa	6⅝	2	4¾	4⅝	16	17⅛	8 IIb	12	4	8¼	7⅛	21½	26⅛
8 VIIa	7	2	4¼	4½	13¾	16⅛	15 VIIa	10⅝	4	8½	7⅛	22½	27⅝
9 VIIa	7½	2	5	4½	14	16⅛	16 VIIa	10⅞	4	8	7⅛	21½	26¾
16 Ic	8½	3	6	5¾	18	19¼	17 VIIa	11⅝	4	7¾	7⅛	21	26½
17 Ic	9⅛	3	6	5½	20	19¾	18 VIIa	12¾	4	8	7½	23	27
6 IIb	8¼	3	5⅞	5½	16¾	19⅞	19 VIIa	13¼	4	8½	7⅞	22½	28
7 IIb	10	3	5½	5⅜	17	20½							

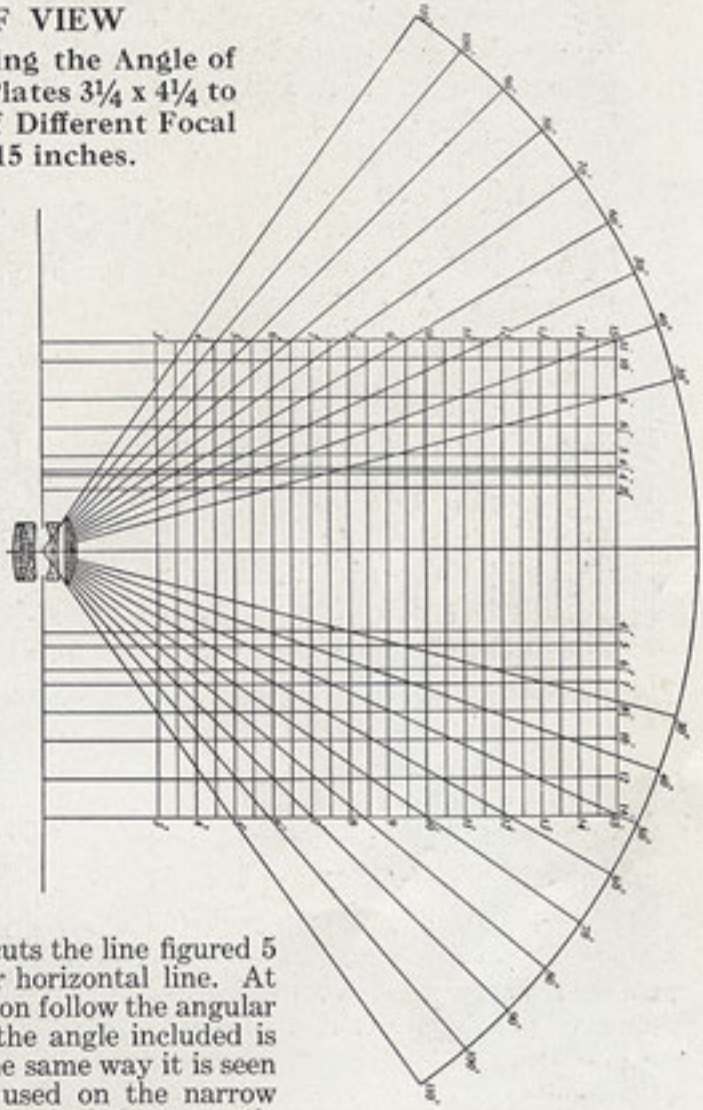
In the above table will be found the combinations which we recommend, together with the magnification and bellows draw for the two extreme magnifications. See price list on page 61.

U. S. Military Prison on Alcatraz Island—Made by R. E. Merville with Protar VIIa, No. 8 and Telephoto Attachment, 5X Magnification

We are indebted to Dr. Julius Martin and the Photo Miniature for permission to reproduce this diagram and accompanying explanation:

ANGLE OF VIEW

A Diagram Showing the Angle of View Included on Plates 3¼ x 4¼ to 11 x 14, by Lenses of Different Focal Lengths from 3 to 15 inches.



To use the diagram, follow the horizontal line, which indicates the base measurement of the plate to be used, until it intersects the vertical line, which indicates the focal length of the lens used. At this intersection, take the nearest angular line and follow it to the arc at the side of the diagram. Here the angle of view included by the lens upon the plate to be used is expressed in degrees.

Examples: What angle of view will be included by a 5-inch lens upon the longest way of a 5 x 7 plate? On the vertical line find the figure 7; follow this line until it cuts the line figured 5 at the lower or upper horizontal line. At the point of intersection follow the angular line to the arc and the angle included is seen to be 70°. In the same way it is seen that the same lens, used on the narrow base (5-in.) of the plate, includes an angle of about 52°, while used on a plate whose base measures 12 inches, we get an angle of 100°.

Table Showing Angular Field Covered with Different Focal Lengths

Plate Inches	Image Circle = Diagonal of Plate	Angular Field with Focus					Plate Inches	Image Circle = Diagonal of Plate	Angular Field with Focus				
		90° In.	80° In.	70° In.	60° In.	50° In.			90° In.	80° In.	70° In.	60° In.	50° In
3¼ x 3¼	4.6	2.3	2.74	3.29	3.98	4.93	6½ x 8½	10.7	5.35	6.38	7.64	9.27	11.47
3¼ x 4¼	5.3	2.65	3.16	3.78	4.59	5.68	8 x 10	12.4	6.2	7.39	8.85	10.74	13.30
4 x 5	6.4	3.2	3.81	4.57	5.54	6.86	10 x 12	15.6	7.8	9.30	11.14	3.51	16.73
4¼ x 6½	8.0	4.0	4.77	5.71	6.93	8.58	12 x 15	19.4	9.7	11.56	13.85	6.80	20.80
5 x 7	8.6	4.3	5.13	6.14	7.45	9.22							

Waterfall in Grimes' Glen, Naples, N. Y.—Made by A. Melzer with Protar VIIa

PRICE LISTS

BAUSCH & LOMB PHOTOGRAPHIC LENSES

TESSAR Ic, F:4.5—*The Lens for Speed*

Code Word	No.	Size of Plate Covered with Stop F:4.5 Inches	Size of Plate Covered with Small Stops Inches	Equivalent Focus Inches	Diameter of Lens Inches	Lens and Barrel with Iris Diaphragm	In Volute Shutter Without Barrel	
							No.	Price
Habit	12	2¼ x 3¼	3½ x 3½	3½	¾	$ 42.00	1	$ 65.00
Haema	13	2½ x 3½	3¼ x 4¼	4½	1 1/32	45.00	1	68.00
Hafter	14	3¼ x 4¼	4 x 5	5½	1¼	52.50	1	75.50
Hagdon	15	4 x 5	4¼ x 6½	6½	1½	62.50	2	87.50
Haggle	15a	5 x 7	5 x 8	7½	1 23/32	75.00	2	100.00
Hail	16	5 x 8	6½ x 8½	8½	1 15/16	92.50	3	119.50
Hairen	17	6½ x 8½	8 x 10	9 7/8	2 3/32	147.50	3	174.50
Hakim	18	8 x 10	10 x 12	11¾	2 11/16	200.00		
Halberd	18a	10 x 12	11 x 14	14¾	3⅜	267.50		
Halfer	19	11 x 14	12 x 16	15⅝	3 9/16	325.00		
Halicore	20	14 x 17	16 x 18	19 7/16	4 7/16	460.00		

For matching lenses for stereoscopic work, add $4.00 to the price of the lenses.

Each lens is furnished in a case which protects it from injury. Lens cap and flange are included.

When ordering lenses to be fitted with shutter, by telegraph, specify *Volute* in addition to the code word for the size of lens.

Tessar Ic is furnished in **Sunk Mount** in Sizes 14 and 15, at an extra charge of $2.25 for No. 14 and $5.00 for No. 15. Regular barrel is not included. When ordering, add *Sunk* to code word or catalog number.

TESSAR Ic, F:3.5—*For Motion Picture Cameras*

In Barrel with Iris Diaphragm

Code Word	Speed	Catalog No.	Covers at Full Opening	Equivalent Focus		Diameter	Price
				In.	Mm.		
Hack	F:3.5	1	¾ x 1	2	50	1 1/32	$37.50
Hade	F:3.5	1a	1¼ x 1¼	3	75	1 23/32	45.00
Hangle	F:4.5		¾ x 1	1¼	32	5/16	40.00

In Spiral Focusing Mount

Code Word	Speed	Catalog No.	Covers at Full Opening	Equivalent Focus		Diameter	Price
				In.	Mm.		
Hackfocus	F:3.5	1	¾ x 1	2	50	1 1/32	$42.50
Hadefocus	F:3.5	1a	1¼ x 1¼	3	75	1 23/32	50.00
Hanglefocus	F:4.5		¾ x 1	1¼	32	5/16	45.00

In Tubes for Rack and Pinion Mount

(Rack and Pinion Mount Extra)

Code Word	Speed	Catalog No.	Covers at Full Opening	Equivalent Focus		Diameter	Price
				In.	Mm.		
Hackrack	F:3.5	1	¾ x 1	2	50	1 1/32	$42.50
Haderack	F:3.5	1a	1¼ x 1¼	3	75	1 23/32	50.00

Rack and Pinion Mount—Complete with flange, suitable for lenses in above table or in connection with adapter below, for Tessar Ic Nos. 15, 15a $7.50

Lens Hood 1.50

Adapter for Tessars No. 15 or 15a, each 3.00

TESSAR IIb, F:6.3—*The Lens for Hand Cameras*

Code Word	No.	Size of Plate Covered with Stops F:6.3 Inches	Size of Plate Covered with Smaller Stops Inches	Equivalent Focus Inches	Diameter of Lens Inches	Lens and Barrel with Iris Diaphragm	In Volute Shutter Without Barrel	
							No.	Price
Hag	2a	2¼ x 3¼	3½ x 3½	3½	9/16	$ 32.50*	1	
Hallux	3	2½ x 3½	3¼ x 4¼	4⅝	11/16	42.50	1	$ 65.50
Halogen	4	3¼ x 4¼	4 x 5	5¼	22/32	45.00	1	68.00
Halones	5	4 x 5	5 x 7	6¼	1 1/32	47.50	1	70.50
Halser	5k	3¼ x 5½	5 x 7	7 1/16	1 3/32	57.50	1	80.50
Halyard	5a	5 x 7	5 x 8	7 1/16	1 3/16	65.00	2	90.00
Hamble	6	5 x 8	6½ x 8½	8⅜	1 7/16	80.00	2	105.00
Hamlet	7	6½ x 8½	8 x 10	10	1 11/16	107.50	2	132.50
Hammock	8	8 x 10	10 x 12	12	2	160.00	3	187.00
Hamper	9	10 x 12	12 x 15	14¼	2 3/8	205.00	3	232.00
Hamular	9a	11 x 14	14 x 17	16½	2 11/32	247.50		
Handbill	10	14 x 17	15 x 20	19 3/16	3 3/32	325.00		
Handsel	11	16 x 20	20 x 24	23¼	3 13/16	417.50		

For matching lenses for stereoscopic work, add $4.00 to the price of the lenses.

Each lens is furnished in a case which protects it from injury. Lens cap and flange are included.

When ordering lenses fitted with shutter, by telegraph, specify *Volute* in addition to the code word for the size of lens.

*Supplied in cells for use on Vest Pocket Kodak.

VIIa CONVERTIBLE PROTAR—F:6.3-F:7.7

The Most Universal Lens Made

Code Word	No.	Size of Plate Covered with Full Aperture Inches	Size of Plate Covered with Small Stops Inches	Combinations of Single Protars Focus, Inches		Combined Equivalent Focus Inches	Speed F	Lens and Barrel with Iris Diaphragm	In Volute Shutter Without Barrel	
				Front Lens	Back Lens				No.	Price
Hem	1	3¼ x 3¼	3¼ x 4¼	7 3/16	7 3/16	4⅛	6.3	$ 65.00	1	$ 88.00
Hematin	2	3¼ x 4¼	4 x 5	8¾	7 3/16	4½	7.0	68.50	1	91.50
Hematite	3	4 x 5	4¾ x 6½	11 3/16	7 3/16	5	7.7	75.00	1	98.00
Hemin	4	4 x 5	4¾ x 6½	8¾	8¾	5 1/16	6.3	72.00	1	95.00
Hemipter	5	4¼ x 6½	5 x 7	11 3/16	8¾	5⅝	7.0	78.50	1	101.50
Hemisect	6	4¼ x 6½	5 x 7	13¾	8¾	6⅛	7.7	88.50	2	113.50
Hemitone	7	4½ x 7¼	5 x 8	11 3/16	11 3/16	6⅜	6.3	84.00	1	107.00
Hemlock	(8)	5 x 7	6½ x 8½	13¾	11 3/16	7	7.0	94.00	2	119.00*
Hempen	9	5 x 8	6½ x 8½	16 3/16	11 3/16	7½	7.7	110.50	2	135.50
Henbane	10	5 x 8	7 x 9	13¾	13¾	7⅞	6.3	103.00	2	128.00
Henotic	11	6½ x 8½	8 x 10	16 3/16	13¾	8½	7.0	119.50	2	144.50
Hepar	12	6½ x 8½	8 x 10	18⅜	13¾	9⅛	7.7	147.00	3	174.00
Hepatica	13	6½ x 8½	8 x 10	16 3/16	16 3/16	9¼	6.3	136.00	2	161.00
Heptad	14	7 x 9	10 x 12	18⅜	16 3/16	10	7.0	163.50	3	190.50
Heptane	15	7 x 9	10 x 12	23¼	16 3/16	10⅞	7.7	192.00	3	219.00
Heptoic	16	7 x 9	10 x 12	18⅞	18⅛	10 1/16	6.3	190.00	3	217.00
Heraldic	17	8 x 10	11 x 14	23¼	18⅛	11⅛	7.0	218.50	3	245.50
Herand	18	8 x 10	11 x 14	27⅛	18⅛	12¾	7.7	257.00	3	284.00
Herbage	19	8 x 10	12 x 16	23¼	23¼	13¼	6.3	240.00	3	267.00
Herbar	20	10 x 12	14 x 17	27⅛	23¼	14 5/16	7.0	278.50	3	305.50
Herd	22	10 x 12	16 x 18	27⅛	27⅛	15½	6.3	312.00	3	339.00
Herdic	25	10 x 12	17 x 20	30¾	30¾	18¼	6.3	429.00		
Hereon	28	11 x 14	18 x 22	33⅞	33⅞	20¼	6.3	563.00		
Heresy	30	12 x 16	22 x 27	39¼	39¼	23⅜	6.3	743.00		

*No. 2 Volute is here regularly supplied. If it is desired to use the lens on a hand camera and No. 2 Volute is not wanted, we can adapt the No. 1 Volute by reducing the diameter of the lens. This in no way affects the speed of the combination. In ordering, kindly specify whether No. 1 or No. 2 Volute is to be furnished.

VII PROTAR—F:12.5

Code Word	No.	Size of Plate Covered with Stop F:12.5 Inches	Size of Plate Covered with Small Stops Inches	Equivalent Focus Inches	Back Focus Inches	Diameter of Lens Inches	Lens and Barrel with Iris Diaphragm	In Volute Shutter Without Barrel	
								No.	Price
Hector	1	4¾ x 6½	5 x 7	7 3/16	7¾	¾	$ 36.50	1	$ 59.50
Hederic	2	5 x 7	6½ x 8½	8¾	9⅜	⅞	40.00	1	63.00
Hedonic	3	6½ x 8½	10 x 12	11 3/16	12¼	1⅛	46.50	1	69.50
Heelless	4	8 x 10	11 x 14	13¾	15	1⅜	56.50	2	81.50
Hegge	5	10 x 12	12 x 16	16 3/16	17½	1 21/32	73.00	2	98.00
Heiress	6	11 x 14	16 x 18	18⅞	20½	1⅞	100.50	3	127.50
Helena	7	12 x 16	18 x 22	23¼	25¼	2	129.00	3	156.00
Helican	8	13 x 16	22 x 27	27⅛	29 11/16	2 3/16	167.50	3	194.50
Heliotype	9	16 x 18	24 x 30	30¾	34	2¾	231.00		
Helix	10	16 x 20	27 x 35	33⅞	37½	3¼	301.50		
Helmet	11	18 x 22	30 x 40	39¼	43½	3¾	394.00		

For matching lenses for stereoscopic work, add $4.00 to the price of the lenses.

When ordering lenses fitted with shutter, by telegraph, specify *Volute*, in addition to the code word for the size of lens.

Each lens is furnished in a case which protects it from injury. Lens cap, flange and screen ring for ray filter are included.

The diaphragm scale is graduated for each focal length.

C SET—BAUSCH & LOMB CONVERTIBLE PROTAR VIIa

With barrel in case, $131.00. Code word, *Hermes.*

Fitted with aluminum Volute Shutter, in case, without barrel, $159.00.

Series	No.	Size of Plate Covered with Largest Stops* Inches	Equivalent Focus of Lenses in Inches			Speed
			Front Lens	Back Lens	Combined Focus	
VII	2	5 x 7	....	8¾	....	F:12.5
	3	6½ x 8½	....	11 3/16	....	F:12.5
	4	8 x 10	....	13¾	....	F:12.5
VIIa	5	4¼ x 6½	11 3/16	8¾	5⅝	F:7.0
	6	4¼ x 6½	13¾	8¾	6⅛	F:7.7
	8	5 x 7	13¾	11 3/16	7	F:7.7

* Larger plates covered with smaller stops.

D SET—BAUSCH & LOMB CONVERTIBLE PROTAR VIIa

With barrel in case, $253.50. Code word, *Heriot.*

Fitted with aluminum Volute Shutter, in case, without barrel, $283.50.

Series	No.	Size of Plate Covered with Largest Stops* Inches	Equivalent Focus of Lenses in Inches			Speed
			Front Lens	Back Lens	Combined Focus	
VII	3	6½ x 8½	....	11 3/16	....	F:12.5
	4	8 x 10	....	13¾	....	F:12.5
	5	10 x 12	....	16 3/16	....	F:12.5
	6	11 x 14	....	18⅞	....	F:12.5
VIIa	8	5 x 7	13¾	11 3/16	7	F:7.0
	9	5 x 8	16 3/16	11 3/16	7½	F:7.7
	9a	5 x 8	18⅞	11 3/16	8	F:7.7
	11	6½ x 8½	16 3/16	13¾	8½	F:7.0
	12	6½ x 8½	18⅞	13¾	9⅛	F:7.7
	14	7 x 9	18⅞	16 3/16	10	F:7.0

* Larger plates covered with smaller stops

MEDIUM WIDE ANGLE—Series IV, F:12.5

Code Word	No.	Size of Plate Covered with Stop F:12.5 Inches	Size of Plate Covered with Small Stops Inches	Equivalent Focus Inches	Diameter of Lens Inches	Lens and Barrel with Iris Diaphragm	In Volute Shutter Without Barrel	
							No.	Price
Harden	1	2½ x 3¼	3½ x 3½	2 7/16	¼	$ 22.00		
Hardock	2	3¼ x 4¼	4 x 5	3 1/8	7/16	22.00	1	$ 45.00
Harem	3	4¼ x 6½	5 x 7	4 11/16	½	26.50	1	49.50
Hark	4	5 x 8	6½ x 8½	6 7/16	5/8	31.00	1	54.00
Harmel	5	6½ x 8½	8 x 10	7 11/16	11/16	41.00	1	64.00
Harmonic	6	10 x 12	12 x 15	10¼	1⅛	59.50	1	82.50
Harness	7	12 x 15	16 x 20	15 7/16	1 5/8	93.50	2	118.50
Harpoon	8	16 x 20	18 x 22	23 11/16	2 5/8	165.00	3	192.00
Harrow	9	20 x 24	24 x 30	35 11/16	2 15/16	374.00		
Hart	10	24 x 30	28 x 36	48 5/8	3⅛	810.00		

For matching lenses for stereoscopic work, add $4.00 to the price of the lenses.

When ordering lenses fitted with shutter, by telegraph, specify *Volute* in addition to the code word for the size of lens.

Each lens is furnished in a case which protects it from injury. Lens cap and flange are included.

EXTREME WIDE ANGLE—Series V, F:18

Code Word	No.	Size of Plate Covered with Stop F:18 Inches	Size of Plate Covered with Small Stops Inches	Equivalent Focus Inches	Diameter of Lens Inches	Lens and Barrel with Iris Diaphragm	In Volute Shutter Without Barrel	
							No.	Price
Hauteur	1	4 x 5	4¼ x 6½	3 5/16	11/32	$ 31.00	1	$ 54.00
Havildar	2	5 x 7	6½ x 8½	4 7/16	7/16	31.00	1	54.00
Hawk	3	6½ x 8½	8 x 10	5 9/16	9/16	37.50	1	60.50
Haybote	4	8 x 10	11 x 14	7 3/16	23/32	46.50	1	69.50
Haytian	5	10 x 12	14 x 17	8½	7/8	58.50	1	81.50
Hazle	6	11 x 14	18 x 22	10 5/16	1 1/16	73.00	1	96.00
Health	7	12 x 15	20 x 24	12 7/16	1¼	87.00	1	110.00
Heard	7a	16 x 18	22 x 27	15 5/8	1 3/32	115.50	1	138.50
Heathen	8	14 x 17	17 x 20	18 5/16	1 3/32	115.50	1	138.50
Heave	9	16 x 18	22 x 27	24 1/8	1½	165.00	2	190.00
Heben	10	20 x 25	24 x 30	37¼	2 3/16	330.00	3	357.00

For matching lenses for stereoscopic work, add $4.00 to the price of the lenses.

When ordering lenses fitted with shutter, by telegraph, specify *Volute* in addition to code word for the size of lens. Each lens is furnished in a case which protects it from injury. Lens cap and flange are included.

BAUSCH & LOMB PROCESS ANASTIGMAT—F:10

Code Word	No.	Equivalent Focus, Inches	Diameter of Lens, Inches	Covers for Same Size Reproduction, Inches	Covers for Reduction, Inches	Price
Kernel	0	13	1⅜	11 x 14	8 x 10	$120.00
Keralo	0a	16	1¾	12 x 15	10 x 12	155.00
Keeler	1	18	2	14 x 17	12 x 15	175.00
Keese	2	25	2⅝	20 x 24	16 x 20	280.00

TELEPHOTO ATTACHMENT

Code Word	No.	Focus, Inches	Fitted to Bausch & Lomb Lenses	Fitted to Lenses of Other Manufacture
Hidden	2	2⅜	$34.50	$ 41.00
Hieron	3	3	44.00	49.50
Highly	4	4	57.50	65.00

In every instance lenses should be sent to us to secure correct adjustment in fitting Telephoto Attachments

BAUSCH & LOMB CONDENSERS FOR ENLARGING

Code Word	No.	Diameter in Inches	Focus in Inches	One Lens Unmounted	Pair of Lenses Mounted
Hispanic	6½D	6½	10	$ 6.75	$20.50
Hispid	8D	8	12	13.50	35.00
Hist	9D	9	14	16.50	42.00
Histoid	10D	10	15	22.00	54.00
Histrion	12D	12	18	40.00	92.00
Histozyme	14D	14	21	55.00	123.00

In telegraph orders add the word *Mounted* to code word when lenses are desired mounted.
(Be sure to state diameter of lens when ordering.)

VOLUTE SHUTTER

Code Word	No.	Will Take Lenses with Opening of	Automatic Exposure	Volute Shutter Only	Fitted to Our Lens—Add	Fitted to Other Lens or Our Lens fitted to Other Shutter Sent—Add
Hitch	1	1	1 sec. to 1/150 sec.	$23.00	$4.50	$6.00
Hitter	2	1 3/16	1 sec. to 1/100 sec.	25.00	5.50	7.00
Hive	3	2	1 sec. to 1/75 sec.	27.00	6.00	8.50

Cable release regularly supplied; if bulb and hose are preferred, specify with order.

BRASS FLANGES FOR BAUSCH & LOMB LENSES

Diameter, In.	1 3/16	1¾	2	2¼	2½	2¾	3	3½	4	4½	5	5½	6
Price, each	$0.85	$1.15	$1.45	$1.55	$1.75	$1.85	$2.00	$3.00	$3.75	$4.60	$5.50	$6.35	$7.50

CAPS FOR BAUSCH & LOMB LENSES

Diameter, Inches	1 3/16	1 5/16	1 11/16	2	2 3/16	2 3/8	2 5/8	2 7/8
Price, each	$0.60	$0.65	$0.70	$0.70	$0.75	$0.80	$0.85	$0.90
Diameter, Inches	3¼	3 5/8	3 7/8	4 1/16	4 3/16	4 3/8	4 5/8	6 1/16
Price, each	$1.00	$1.25	$1.40	$1.50	$1.60	$1.75	$2.00	$2.90