

About Lenses



Canadian Kodak Co., Limited
Toronto, Canada

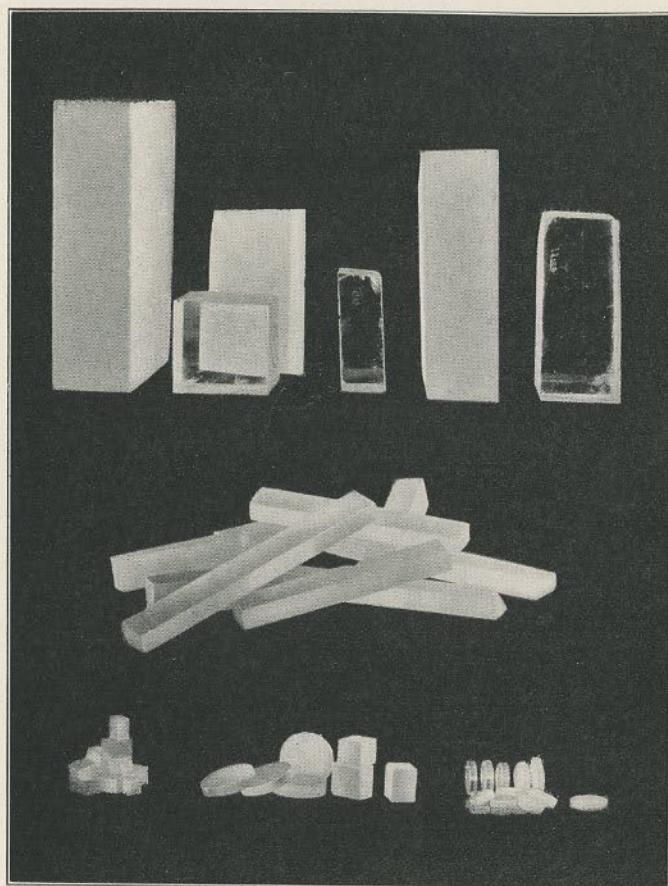
About Lenses



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Toronto, Canada

1922



FIRST STAGES IN LENS MAKING

Optical glass from which Kodak Anastigmat lenses are made is delivered in slabs such as those illustrated at the top of this page. The large slab, on the left, is ten inches high.

After passing exhaustive tests to prove its flawlessness and to determine its index of refraction each slab is cut into sticks by diamond-impregnated circular saws.

The sticks are then sawed into cubes which are melted in gas furnaces and pressed into discs. The discs are annealed by gradual cooling in an electric oven. Then they must pass tests for flaws and strain before they are admitted to the grinding rooms. There, in a long series of operations and inspections, they are ground and polished to within $1/30,000$ of an inch of perfection.

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CHAPTER I.

How A Lens Forms An Image

In order to take a photograph we use a lens which forms an image of the object we want to photograph upon the film.

The simplest lens which we could use would be a small hole. If we take a sheet of cardboard and make a hole in it with a pin, and then, in a darkened room, hold the cardboard between a sheet of white paper and an electric lamp, we shall see on the paper an image of the lamp filament.

The diagram shows how this image is produced. A ray of light from each portion of the filament passes through the pinhole and forms a spot of light on the paper, and all these spots joining together form the image of the filament.

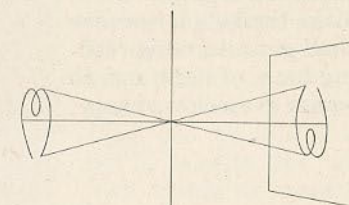


Fig. 1.

If we take the lens out of a camera and replace it by a thin piece of metal pierced with a hole made by a needle (a No. 10 sewing needle is about right, and the edges of the hole must be beveled off so that they are sharp), then we can take excellent photographs by giving sufficient exposure.

If the pinhole is about six inches from the film then an exposure of about one minute for an outdoor picture on film will be required. It is necessary, of course, to make a well fitting cap for the lens aperture so that no light will get in except through the pinhole, and also to make a cover for the pinhole to act as a shutter for exposing.

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But if a pinhole were the only means of forming an image it is very improbable that photography would ever have been developed, since the exposures are so long in consequence of the small amount of light which can pass through the pinhole.

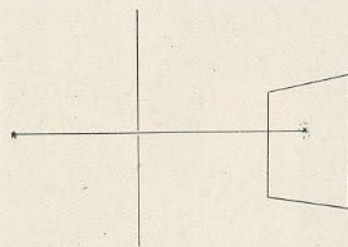


Fig. 2

In order to get more light we could try making the pinhole larger, but the effect of this is to make the image very indistinct, and even the smallest efficient pinhole can not give as sharp an image as a good lens.

Suppose we have a small pinhole forming an image of a star, as shown in Fig. 2. If we make the hole larger, we shall get a round, spreading beam of light and no longer get a sharp image.

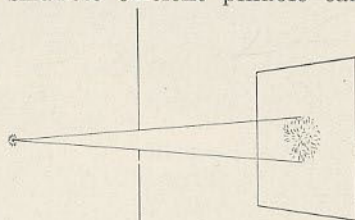


Fig. 3

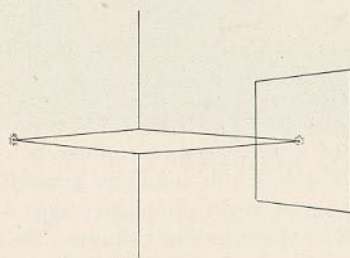


Fig. 4

If a ray of light falls on a piece of glass so that it is not perpendicular to it, it will be bent. There is an interesting experiment which shows this very well. Take a thick block of glass and place it so that it touches a pin (which is marked B in Fig. 5) and stick another pin (A) in the board. Now look through the glass and stick a pin (D) between your eye and the glass,

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and in the same line of sight as A and B, and lastly another pin (C) touching the glass and in the same line of the sight as the other three.

Take away the glass and join up the pinholes with pencil lines. You will find that the line DC is parallel to the line AB but is not in the same line; that is, the ray of light marked by the line AB was bent when it entered the glass and then bent back again when it left it, so we can bend light by means of glass.

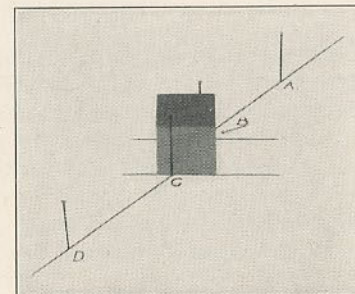


Fig. 5

If we take a triangular piece of glass (called a prism)

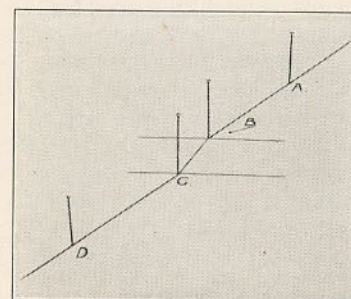


Fig. 6

we can bend a ray when it enters the glass and also more still when it leaves the glass. (Fig. 7.) And a lens is really two prisms stuck together base to base (Fig. 8). So that if we put a lens in the hole with which we want to form an image, we can do what we wish to and make all the rays from

the star come together again in the image of the star. This is the purpose of our camera lenses, to form an

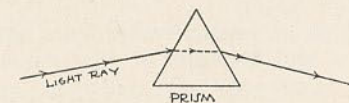


Fig. 7

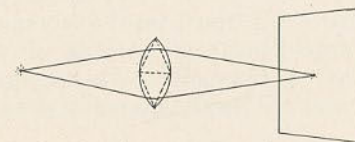


Fig. 8

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image as sharp as that given by the smallest pinhole and yet much brighter than any pinhole could give.

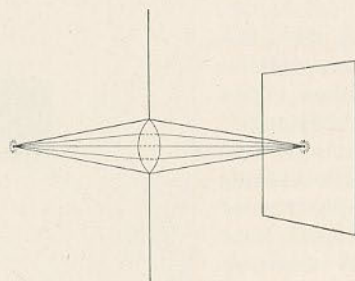


Fig. 9

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CHAPTER II.

Focal Length

Should we place a pinhole, instead of a lens, in the front-board of our camera, we could use the same size of pinhole for making all sizes of pictures, because the image formed by a pinhole is always of the same sharpness, whether the pinhole is far from the film or close to it. If we want a large picture we must, of course, use a large camera with a long bellows, so the pinhole will be a long way from the film, while if we want a small picture we will only need a small camera with a short bellows, so the pinhole will be near the film. But if, instead of a pinhole, we use a lens, we will find that the lens must be placed at a certain distance from the film (depending upon its focal length and its distance from the object photographed) in order to obtain a sharp picture. If it is placed at any other distance from the film the picture will be all blurred. The reason for this is that a photographic lens bends the rays of light that pass through it so that all the light rays from a star, for instance, will meet again to form an

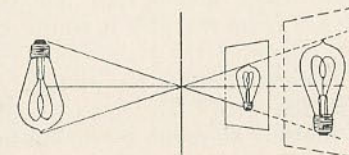


Fig. 10

image of the star. By placing a sheet of cardboard at the position where the rays of light meet, the image of the star will be sharp, but

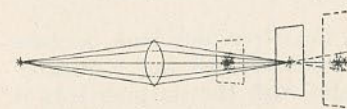


Fig. 11

if we put the card either nearer to or farther from the lens, the image will be blurred into a circle of light. The distance at which the lens must be placed from the film to give a sharp image represents the "focal length" of the lens.

The longer the focal length of a lens the larger the image, and the shorter the focal length the smaller the image. Suppose we photograph a tree and place the camera at such a distance from the tree that with a lens

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of three inches focal length we obtain a picture in which the image of the tree is one inch long.

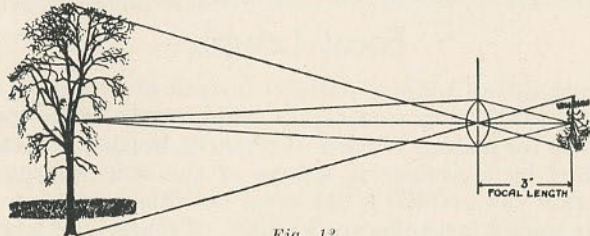


Fig. 12

Now if, with the camera at the same distance from the tree, we had used a six-inch lens instead of the three-inch lens, which means that instead of the lens being three inches from the film it would be six inches from it, then the image of the tree would be two inches long instead of one inch long in the picture. If we were using the same size film with both lenses, of course we would not be able to include as much of the subject we were photographing in the field of view of the picture made with the six-inch

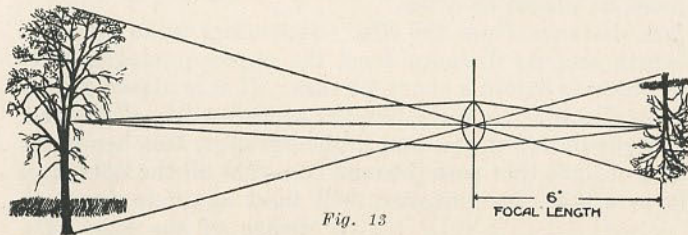


Fig. 13

lens as we would obtain with the three-inch lens, because with the three-inch lens the tree would be, say, a quarter of the length of the film, while with the six-inch lens it would be half the length of the film. In other words, the three-inch lens would give us a smaller image, while the six-inch lens would give us a large image of the tree.

The longer the focal length of a lens, the less we include in our picture, and the larger the images of objects are, while the shorter the focal length, the more we include in the picture and the smaller the images are.

In actual practice we must compromise between a lens which will include as large an area as possible in the field of view, and a lens which will give images as large as possible; consequently, for general all-around

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purposes it is best to use a lens whose focal length is somewhat greater than the longest side of the film. For $2\frac{1}{2} \times 4\frac{1}{4}$ film, for instance, we would use a lens of about 5 inches focal length.

It is most important not to use a lens of too short a focal length for the size of the film employed. There is a great temptation to do this. While a lens of $4\frac{1}{2}$ -inch focus as compared with a lens of three-inch focus means a big lens in place of a little lens, and a larger shutter and a somewhat larger camera in place of a smaller shutter and an extremely compact camera, it also means (and this is vastly more important than mere camera compactness) the making of pictures having good perspective instead of pictures with bad perspective; in other words, it means pictures whose drawing looks right instead of pictures whose drawing looks wrong. The reason for this is that the perspective of a picture is determined by the point of view from which the lens makes the picture. If this perspective is not pleasing to the eye it will not be pleasing in the picture.

Fig. 14 shows a picture made with a very short focus lens used close to the subject. This is a faithful rendering of the perspective that the eye saw from the view-point of the lens, and is far from pleasing.

In Fig. 15 the same subject is shown photographed with a long focus lens, and in this picture the perspective is pleasing. It likewise represents the perspective that the eye saw from the view-point of the lens.

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Fig. 14

This is a truthful rendering of the perspective that the eye saw from the viewpoint of the short focus lens.



Fig. 15

The perspective as the eye saw it from the viewpoint of the long focus lens.

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CHAPTER III.

Why Cameras Have Different Kinds of Lenses

The smaller the camera, or rather the smaller the picture, the greater the inclination to take "close-up" views—those little intimate pictures that we all so much enjoy. We naturally work close to the subject so as to have the *principal object* occupy as large a proportion of the picture area as possible. We have shown that it is the working close up with a short focus lens that brings bad perspective, and that with a long focus lens we can obtain good perspective and still get the large image we desire without working close up. For instance, if you want an image two inches high in a $2\frac{1}{4} \times 3\frac{1}{4}$ picture, and you find you must be six feet from the subject to get this image with a three-inch lens, you can get this same size of image in your picture with a $4\frac{1}{2}$ -inch lens at nine feet distance; and working nine feet instead of six feet from the subject means obtaining much better perspective.

It is a good rule to secure a lens which has a focal length at least equal to the diagonal of the film. A little more focal length is still better.

Lenses differ in another respect than their focal length. They differ in the amount of light they admit, and this is very important, because the more light admitted, the shorter the exposure can be. The chief object in using a lens instead of a pinhole is to transmit more light to the film, and the amount of light that is transmitted depends upon the area of the glass in the lens.

Suppose we place a piece of cardboard, instead of a film, in the back of a camera, and have a pinhole in the card through which we can look at the lens; then point the lens towards a window; the amount of light that reaches the eye through the hole in the card depends upon how much of the light from the window is passing through the lens; that is to say, it will depend on the area of the window which we could see if there was no glass in the lens. Since the visible area of the window is

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bounded by the edges of the lens mount, we could see more if the lens were of shorter focal length so that the eye was closer to it. With a lens of long focal length only a small part of the window area is visible.

With a lens of half the focal length, but of the same diameter as that shown in Fig. 17, four times as much of the window area is visible.

This shows that the brightness of the image projected by lenses of the same diameter varies inversely as the square of the focal length of the lens. It also varies as the area of the lens surface (aperture) which admits the light. The greater the lens aperture the more light it admits. The area of the lens aperture, of course, is proportional to the square of the diameter, so that all lenses

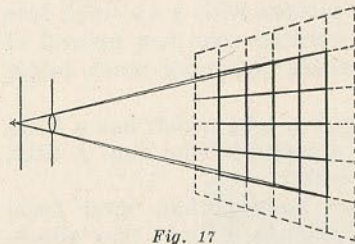


Fig. 17

in which the diameter of the aperture bears the same ratio to the focal length will give equally bright images. This means that the brightness of the image is determined not solely by the focal length, nor solely by the diameter of the lens aperture, but by the *relation* that exists between the lens aperture and the focal length of the lens, so that all lenses in which the diameter of the opening is, say, one-sixth of the focal length, will give equally bright images. Thus, in a lens of one-inch aperture and a focal length of six inches, the opening is one-sixth of the focal length, and in a lens of twelve inches focal length and two inches aperture, the opening is likewise one-sixth of the focal length. Both lenses are of the same *f.* value. This means that both give an image of the same brightness, and will require the same exposure. Lens "apertures" are, therefore, rated according to the ratio between their diameters and their focal lengths; thus, one in which the opening is one-sixth of the focal length is

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marked *f.* 6; one in which the opening is one-eighth, *f.* 8, and so on, and the larger the aperture, the more light the lens transmits, and the more light it transmits the shorter the exposure needed.

While large lens apertures have the advantage of permitting shorter exposures, they have some disadvantages. In the first place, to get a large aperture we must have a *large lens*, and this means an expensive lens; also, the errors of definition, which are called the "aberrations" of lenses, increase very much as the apertures increase, so that only the very best types of lenses in which these aberrations are removed to as great an extent as possible, can be made of large aperture and still give a good definition. Large aperture lenses are therefore costly.

But even when we have a lens with a large aperture we shall have to regard this as a reserve power for use in special circumstances, and we shall not by any means be able to use it at its largest aperture all the time.

CHAPTER IV.

Depth of Focus

From the construction of a lens it follows that only the rays from a mathematical point can come together in a point again, and that the rays from any point nearer or farther than the point focused can not meet in a point image on the film, but must produce a small disc of light instead of a sharp point of light. (See Fig. 11.)

The disc is termed the *circle of confusion*. If the circle of confusion is small enough we shall not be able to distinguish it from a point, and the picture will appear to be sharp.

With what are known as "fixed focus" cameras such as some of the Vest Pocket Kodaks and the Box Brownies, no attempt is made to secure a wholly sharp focus for objects at all distances, but the cameras are sharply focused on the nearest point to the camera which will still enable distant objects to appear approximately sharp in the pictures, and in this way objects in the middle distance are perfectly sharp, and near objects are also sharp provided they are not too near.

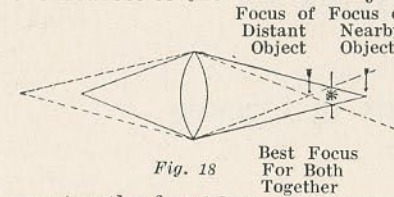
The following table of these distances, beyond which everything is sharp when the largest stop is used, may be useful:

Vest Pocket Kodak (Meniscus Achromatic Lens)	10½ feet
No. 0 Brownie	10½ feet
No. 2 Brownie	14 feet
No. 2A, 2C and No. 3 Brownie.....	15 feet

If we are using a No. 2 Brownie, for instance, as long as everything is farther off than fourteen (14) feet we can rely on getting a picture with everything focused sharply.

With the focusing Kodaks we must judge the distance of the object on which we wish the focus to be sharpest and set the scale to that; then we shall find that objects somewhat nearer, and also objects a good deal farther

from the camera are also sharp, and the distance from the nearest to the farthest objects that appear sharp in

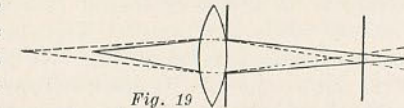


the negative is called the "depth of focus."

This depth of focus depends on the focal length of the lens and on the size of stop used in the lens; the

greater the focal length the less the depth of focus, and the *bigger the stop the less the depth of focus*. Thus in Fig. 18, we have a lens focusing near and far points at full aperture and producing large circles of confusion. In

Fig. 19 a smaller stop is used in the same lens, and the circles diminish in size in proportion to reduction in the size of the stop.



Sometimes we have to focus near objects at the same time as distant ones, so that it is necessary to "stop the lens down" to some extent.

Stops are marked on two different systems, though both are based on the fundamental ratio of the diameter to the focal length of the lens. In the one system the stop is expressed simply as a fraction of the focal length; thus $F./8$ (commonly written $f.8$) means that the aperture is one-eighth of the focal length of the lens; $f.16$, one-sixteenth, and so on. The rectilinear lenses fitted to Kodaks are, however, marked in the "Uniform System" (U.S.) in which the numbers are proportional to the exposure required, $f.4$ being taken as unity, so that the scale is as follows:

F.	$f.4$	$f.5.6$	$f.6.3$	$f.8$	$f.11$	$f.16$	$f.22$	$f.32$	$f.45$
U.S.	1	2	2½	4	8	16	32	64	128

This table also shows the relative exposure that is required with the $f.$ system stops, the exposure varying as the square of the f value, so that $f.11$ requires twice the exposure of $f.8$; $f.16$ twice that of $f.11$ and so on.

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CHAPTER V.

The Lens to Choose

Kodaks, Premo and Brownie cameras are listed with several different kinds of lenses, the smaller cameras being listed with either Meniscus, Meniscus Achromatic, Rapid Rectilinear or Anastigmat Lenses. The larger cameras have either Rapid Rectilinear or Anastigmat Lenses, while the Special Kodaks and Graflex cameras have Anastigmats only. The Box Brownies are equipped with Meniscus or Meniscus Achromatic Lenses, while with the Folding Brownies there is a choice between Meniscus Achromatic and Rapid Rectilinear lenses.

Many people do not understand the meaning of these terms, and while it is a safe rule to choose the best lens which can be afforded, certain that the better lens is worth the extra cost, it is still better to understand the properties of the different kinds of lenses and what advantages can be gained from the use of the higher grades.

The simplest lenses which can be used are made of a single piece of glass, the form of the lens being of the type which gives the best definition; that is, a Meniscus or crescent shape, and the lenses are called Meniscus (not Meniscus Achromatic) lenses. Such a Meniscus lens can only be used in a fixed focus camera where the maker of the camera has put it in the correct position for forming a sharp image upon the film, but if such a lens were used in a focusing camera we should find that however carefully we focused the picture on the ground glass the negatives would not be sharp, unless the difference between the focusing point of the visual rays by which we focus, and the chemical rays which affect the film was provided for.

This is because a non-achromatic lens bends the rays of light of different colors to different extents, so that the yellow rays which we use for focusing do not come to a focus in the same place as the blue rays which affect the film, because the blue rays are bent more than the yellow.

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In 1752, Dollond, an English optician, showed that by combining two different kinds of glass to make a lens he could get the blue rays to focus at the same point as the yellow rays, and lenses made in this way were called "achromatics," from the Greek words *a* meaning not, and *chroma* meaning color. The best shape of achromatic lens to use is shown in Fig. 21, and since this is also of a "meniscus" or crescent shape the lenses are called meniscus achromatics. If a single achromatic lens is used, it is necessary to "stop it down" so that only a small portion of the lens is used, because the rays which come through the edges do not focus together as well as those which come through the centre, and so the image is not quite sharp if the whole lens area is used.

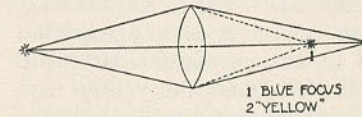


Fig. 20

This stopped-down meniscus lens has the effect of producing slight curvature of the edges of the picture, which does not matter in landscape work or portraiture; but if subjects containing straight marginal lines are photographed with such a lens, their outer lines appear slightly curved—so slightly, however, that the effect is negligible unless the image of the subject so crowds the picture area that its outer lines are very near the margins of the picture, as shown by figures 22 and 23, which represent a window sash photographed with a meniscus lens at short range.

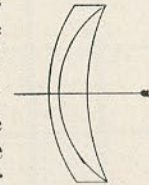


Fig. 21

If the stop is in front of the lens the curvature is in one direction, and if it is behind the lens the curvature is in the opposite direction, so that if we put two achromatics together with the stop between them, the curvature is neutralized and we get a lens which gives no curvature at all.

Such a lens is called a "Rapid Rectilinear"—rectilinear because it gives straight-line images, and rapid because having a focal length half that of either of the component achromatics with a stop of the same diameter, it passes four times as much light and only requires one-quarter of the exposure. The name Rapid Rectilinear

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is now applied to other lenses that give rapid, rectilinear results, although their construction differs from the original type. Rapid Rectilinears are sometimes called by other names, such as "Rapid Aplanats," "Planatographs," and so on. Now, it so happens that the two kinds of glass used in an achromat must fulfill certain conditions to bring the blue and the yellow rays to the same focus, and must fulfill certain other conditions to get a picture which is flat, that is, a picture that is sharp on a flat plate or film; and the ordinary glasses which are used for making achromats will not fulfill all these conditions at once, so that the lenses made with "old" achromats will not give flat field images, the image

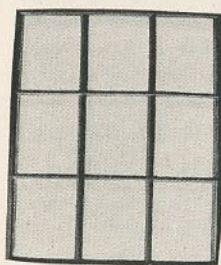


Fig. 22
Made with Stop Behind
Meniscus Lens

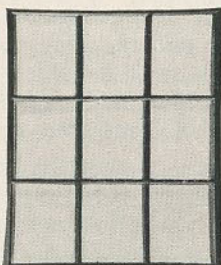


Fig. 23
Made with Stop in Front
of Meniscus Lens

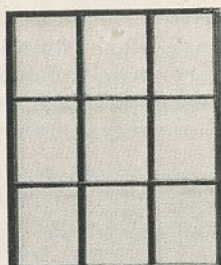


Fig. 24
Made with Rectilinear
Lens

being saucer-shaped. These lenses are, therefore, said to be "astigmatic," which means that they do not give sharp-point images of points.

About thirty years ago, Professor Abbe and Otto Schott, working together at Jena, found out how to make new kinds of optical glass from which lenses could be made which would give flat field images with the blue and yellow rays of the same focus.

By the use of these new glasses the opticians have been able to make lenses that give sharp images on a flat field to the very edge of the picture and, therefore, these lenses are called "Anastigmats," meaning "not astigmatic," this better defining power can, however, only be obtained by the most careful and skilled work in making the lens, this work being of a far higher quality than that employed on the older types of lenses, which accounts for the higher cost of anastigmats.

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Anastigmat lenses can be used with larger stops than any of the older lenses, so that if an Achromatic working at $f.16$ requires a $1/5$ second exposure, a Rapid Rectilinear working at $f.8$ will require a $1/20$ second exposure, and an Anastigmat working at $f.6.3$ will require a $1/32$ second exposure.

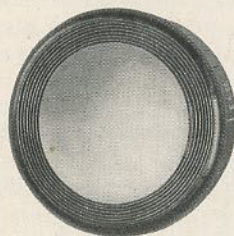
The Kodak Anastigmat is a new lens which has been developed by the Eastman Kodak Company to meet its own requirements, and which is made in a newly equipped factory especially for the Kodak cameras.

As a rule, Anastigmat Lenses are made to serve a dual purpose. A lens that is to cover, say a 4×5 plate at its largest opening, is intended also for a 5×7 plate as a wide angle lens when used with a smaller stop. It is therefore corrected to hit the happy medium and serve both purposes; the Kodak Anastigmats, being designed especially for the size of camera for which they are listed, are corrected to cover only that particular size, the result being that they give the *utmost in efficiency for the specific purpose for which they are designed*, and they can be made and sold at a lower price than lenses which have to serve two purposes. For Kodak use you can not get better lenses than the Kodak Anastigmats, at any price.

As to the aperture at which a Kodak lens should work, it must be remembered that while increase of aperture means a gain of speed, and the possibility of giving shorter exposure in dull weather, it also means a loss of depth of focus, and as a general rule it can be assumed that it is not advisable to use a Kodak lens at a larger aperture than $f.6.3$, so that although we list lenses working at $f.4.5$, for use on $2\frac{1}{4} \times 3\frac{1}{4}$ cameras, their use at this aperture must be so limited that we do not recommend customers, except very skilled ones, to go to the extra expense of obtaining these lenses, since we regard $f.6.3$ as the maximum aperture suitable for general use on cameras other than those of the Graflex type.

The Portrait Attachment

The Portrait Attachment is a supplementary single meniscus lens which is intended to shorten the effective focus of the lens over which it is placed, so as to make it possible to focus objects at a short distance without too great an extension of the camera bellows.



The Portrait Attachment slips over the regular lens

With the ordinary Kodak the extension of bellows will not permit subjects to be focused which are nearer than six feet, while with the Box Brownies, which have no focusing attachment, photographs will not be sharp at distances nearer than those already given on page 14, unless the Portrait Attachment is used. The Portrait Attachment therefore enables one to place the camera nearer the subject and thus obtain larger sharply focused images than would otherwise be possible. It is especially adapted for making portraits, photographing flowers and other objects at short range, but is not intended for photographing landscapes or any distant objects.

The Application

To summarize the advantages and disadvantages of the three types of lenses discussed in the preceding pages:

The single lenses (meniscus and meniscus achromatic) must be used with a relatively small stop, which means that they are somewhat slow. They are fast enough for snap shots in good light, the shutters they are fitted with being adjusted for the making of moderately slow "snaps." The very fact that they require a small stop gives them great depth of focus, however, and for that reason errors in focusing are largely compensated for, resulting in a high percentage of successful pictures.

The Rapid Rectilinear lenses have more speed than the single lenses, and are also better for architectural work (see page 17).

The Anastigmat, $f. 6.3$ lenses are about sixty per cent faster than the Rapid Rectilinear lenses and are corrected for the finest definition (sharpness). When used at their full speed—that is, with the largest opening—they require accurate focusing, although it should be borne in mind that both the length of focus and the stop opening affect this matter of depth of focus. That is why the 3A, the largest of the Kodaks, requires more accurate focusing than the smaller ones and is why, when we get down to the Vest Pocket size, it is possible to use an Anastigmat lens with a fixed focus.

This leads up to a point the amateur should remember. An Anastigmat lens does not require any more accurate focusing than any other lens when used with the *same stop*. Take, for instance, an average landscape with a prominent object in the foreground. The correct stop would be $f.16$ and, if the sun were shining, the correct exposure $1/25$ of a second. You should use this same stop and exposure whether you have a Single lens, a Rapid Rectilinear or an Anastigmat, and the depth of focus with the same focal length of lens would be the same in all cases—no more accurate focusing would be required with one lens than with another.

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But when the light is not very good and you use your Anastigmat at its full opening, or nearly its full opening, in order to get a well-timed snap shot, you have gained tremendously in speed but you have lost *depth* of focus. The object at the focused distance will photograph even sharper than it would with the Single or Rapid Rectilinear lenses, but objects a little nearer the camera or a little farther away will not be so sharp because depth of focus has been sacrificed for speed. And, of course, this same thing is true in using a large stop in order to arrest the motion of moving objects. With a fixed focus camera working at a fixed shutter speed, all still objects, at say, fifty feet away, would be sharp and, with a good light, fully timed, but moving objects might show a blur. With your Anastigmat lens opened to $f. 6.3$ and a shutter speed of $1/200$ of a second, you can arrest moderately fast motion and get a fully timed negative (with good light), but in such case you must focus accurately.

On the 3A and 1A Special Kodaks there is now a device called the Kodak Range Finder by which you can quickly and accurately bring your camera to a correct focus; can make sure of absolute sharpness even with the largest stop. What you should bear in mind, in the selection of a lens, is, however, that used in the same way as the less rapid lenses—that is, with the same stops—the Anastigmat lenses are just as simple to use as the single lenses. It is only when you open the throttle and call on their great reserve power that greater accuracy in focusing becomes necessary.

They will do anything that the cheaper lenses will do and as easily. They will do far more when you call on them.

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Depth of Focus Tables

Depth of focus, as stated in Chapter IV, is the distance from the nearest to the farthest objects that appear sharp in the negative or print. The depth of focus of any lens depends upon the relation between the focal length of the lens and the size of the stop or diaphragm used.

In the tables on the following pages the range of critical definition is given for lenses of various focal lengths, when focused with different stops on points that are at different distances from the lens.

Critical definition is based upon a circle of confusion of $1/200$ of an inch.

TABLE No. I

For Lenses commonly
used on Cameras making
pictures $3\frac{1}{4} \times 5\frac{3}{8}$.

3A Autographic Kodak Special;
3A Autographic Kodak Junior;
3A Folding Cartridge Premo;
3A Premos, Nos. 8 and 9;

3A Autographic Kodak;
3A Folding Autographic Brownie;
3A Premoette Senior.

Anastigmat	$f/6.3$	$f/7.7$ & 8	$f/11$	$f/16$	$f/22$	$f/32$	$f/45$
Rapid Rectilinear	—	U.S. 4	U.S. 8	U.S. 16	U.S. 32	U.S. 64	U.S. 128
Meniscus Achromatic	—	—	No. 1	No. 2	No. 3	No. 4	—

Distance Focused

Upon	ft.	ft.	ft.	ft.	ft.	ft.	ft.
100 ft.	55 to inf.	49 to inf.	40 to inf.	32 to inf.	25 to inf.	20 to inf.	15 to inf.
50	35 " 82	33 " 105	29 " inf.	24 " inf.	20 " inf.	17 " inf.	13 " inf.
25	21 " 31	20 " 34	19 " 40	17 " 52	15 " 93	12 " inf.	10 " inf.
15	13 $\frac{3}{8}$ " 17	13 " 18	12 " 19	11 " 21	10 " 26	9 " 38	8 " 112
12	10 $\frac{3}{4}$ " 13	10 $\frac{1}{2}$ " 13 $\frac{1}{2}$	10 $\frac{1}{4}$ " 14 $\frac{1}{2}$	9 $\frac{3}{4}$ " 16	9 " 18	8 " 23	7 $\frac{1}{2}$ " 37
10	9 $\frac{1}{2}$ " 11	9 $\frac{1}{4}$ " 10 $\frac{3}{4}$	9 " 11 $\frac{1}{2}$	8 $\frac{1}{2}$ " 12	8 " 14	7 $\frac{1}{2}$ " 17	7 " 22
8	7 $\frac{3}{4}$ " 8 $\frac{3}{8}$	7 $\frac{1}{2}$ " 8 $\frac{1}{2}$	7 $\frac{1}{4}$ " 9	7 " 9 $\frac{1}{2}$	6 $\frac{3}{4}$ " 10	6 $\frac{1}{4}$ " 11 $\frac{1}{2}$	5 $\frac{3}{4}$ " 14
6	5 $\frac{5}{8}$ " 6 $\frac{1}{8}$	5 $\frac{3}{4}$ " 6 $\frac{1}{4}$	5 $\frac{1}{2}$ " 6 $\frac{1}{2}$	5 $\frac{1}{4}$ " 6 $\frac{3}{4}$	5 $\frac{1}{2}$ " 7	5 " 7 $\frac{1}{4}$	4 $\frac{3}{4}$ " 8 $\frac{3}{4}$

"Inf." is the abbreviation for Infinity—meaning an infinite distance from the lens.

TABLE No. II

For Lenses commonly
used on Cameras making
pictures $2\frac{7}{8} \times 4\frac{1}{8}$.

2C Autographic Kodak Junior; 2C Folding Autographic Brownie;
2C Folding Cartridge Premo.

Anastigmat	$f/7.7$	$f/11$	$f/16$	$f/22$	$f/32$	$f/45$
Rapid Rectilinear	U.S. 4	U.S. 8	U.S. 16	U.S. 32	U.S. 64	U.S. 128
Meniscus Achromatic	—	No. 1	No. 2	No. 3	No. 4	—

Distance Focused

Upon	ft.	ft.	ft.	ft.	ft.	ft.
100 ft.	42 to inf.	34 to inf.	27 to inf.	21 to inf.	16 to inf.	12 to inf.
25	19 " 38	17 " 48	15 " 75	13 " inf.	11 " inf.	9 " inf.
15	13 " 19	12 " 21	11 " 25	10 " 33	8 $\frac{1}{2}$ " 69	7 " inf.
10	9 " 11	8 $\frac{1}{2}$ " 12	8 " 13	7 $\frac{1}{2}$ " 15	7 " 20	6 " 37
8	7 $\frac{1}{2}$ " 9	7 $\frac{1}{4}$ " 9 $\frac{1}{4}$	7 " 10	6 $\frac{1}{2}$ " 11	6 " 13 $\frac{1}{2}$	5 $\frac{1}{2}$ " 18 $\frac{1}{2}$
6	5 $\frac{1}{2}$ " 6 $\frac{1}{4}$	5 $\frac{1}{4}$ " 6 $\frac{1}{2}$	5 " 6 $\frac{3}{4}$	4 $\frac{3}{4}$ " 7	4 $\frac{1}{2}$ " 7 $\frac{3}{4}$	4 " 9

"Inf." is the abbreviation for Infinity—meaning an infinite distance from the lens.

For Lenses commonly
used on Cameras making
pictures $3\frac{1}{4} \times 4\frac{1}{4}$ and $2\frac{1}{2} \times 4\frac{1}{4}$.

TABLE No. III

No. 3 Autographic Kodak Special; No. 3 Autographic Kodak;
Stereo Kodak; No. 1A Autographic Kodak Special;
No. 1A Autographic Kodak; No. 1A Autographic Kodak Junior;
No. 2A Folding Autographic Brownie; Premoette Seniors Nos. 1 and 3;
Folding Cartridge Premo No. 2A.

	$f/6.3$	$f/7.7 \text{ \& } 8$	$f/11$	$f/16$	$f/22$	$f/32$	$f/45$
Anastigmat	—	U.S. 4	U.S. 8	U.S. 16	U.S. 32	U.S. 64	U.S. 128
Rapid Rectilinear	—	—	No. 1	No. 2	No. 3	No. 4	—
Meniscus Achromatic	—	—	—	—	—	—	—
Distance Focused							
Upon	ft.	ft.	ft.	ft.	ft.	ft.	ft.
100 ft.	42 to inf.	35 to inf.	28 to inf.	21 to inf.	17 to inf.	12 to inf.	9 to inf.
50	29 " 170	26 " inf.	21 " inf.	18 " inf.	14 " inf.	11 " inf.	$8\frac{1}{2}$ " inf.
25	19 " 39	$17\frac{1}{2}$ " 46	$15\frac{1}{2}$ " 68	$13\frac{1}{2}$ " inf.	11 " inf.	9 " inf.	$7\frac{1}{2}$ " inf.
15	$12\frac{1}{2}$ " 19	$11\frac{3}{4}$ " 20	$10\frac{3}{4}$ " 24	$9\frac{3}{4}$ " 32	$8\frac{3}{4}$ " 61	$7\frac{1}{2}$ " inf.	$6\frac{1}{4}$ " inf.
10	9 " $11\frac{1}{2}$	$8\frac{1}{2}$ " 12	8 " 13	$7\frac{1}{2}$ " 15	7 " 20	6 " 32	5 " inf.
8	$7\frac{1}{2}$ " 9	$7\frac{1}{4}$ " $9\frac{1}{4}$	7 " $9\frac{3}{4}$	$6\frac{1}{2}$ " $10\frac{1}{2}$	6 " 13	$5\frac{1}{2}$ " 17	$4\frac{3}{4}$ " 34
6	$5\frac{3}{8}$ " $6\frac{1}{2}$	$5\frac{1}{2}$ " $6\frac{3}{4}$	$5\frac{1}{4}$ " 7	5 " $7\frac{1}{2}$	$4\frac{3}{4}$ " 8 $\frac{1}{2}$	$4\frac{1}{2}$ " 10	4 " 14

Fixed focus cameras
are focused upon 25
feet.

"Inf." is the abbreviation for Infinity—meaning an infinite distance from the lens.

For Lenses commonly
used on Cameras making
pictures $2\frac{1}{4} \times 3\frac{1}{4}$.

TABLE No. IV

No. 1 Autographic Kodak Special; No. 1 Autographic Kodak Junior;
No. 2 Folding Autographic Brownie; Premo No. 12; Pocket Premo;
Folding Cartridge Premo No. 2.

	$f/6.3$	$f/7.7 \text{ \& } 8$	$f/11$	$f/16$	$f/22$	$f/32$	$f/45$
Anastigmat	—	U.S. 4	U.S. 8	U.S. 16	U.S. 32	U.S. 64	U.S. 128
Rapid Rectilinear	—	—	No. 1	No. 2	No. 3	No. 4	—
Meniscus Achromatic	—	—	—	—	—	—	—
Distance Focused							
Upon	ft.	ft.	ft.	ft.	ft.	ft.	ft.
100 ft.	33 to inf.	29 to inf.	22 to inf.	17 to inf.	13 to inf.	9 to inf.	7 to inf.
50	25 " inf.	22 " inf.	18 " inf.	15 " inf.	11 " inf.	$8\frac{1}{2}$ " inf.	$6\frac{1}{2}$ " inf.
25	17 " 49	$15\frac{1}{2}$ " 66	14 " inf.	$11\frac{1}{2}$ " inf.	$9\frac{1}{2}$ " inf.	$7\frac{1}{2}$ " inf.	6 " inf.
15	12 " 21	11 " 24	10 " 31	$8\frac{3}{4}$ " 59	$7\frac{1}{2}$ " inf.	$6\frac{1}{2}$ " inf.	5 " inf.
10	$8\frac{3}{4}$ " $12\frac{1}{2}$	8 " 13	$7\frac{1}{2}$ " 15	7 " 19	6 " 32	$5\frac{1}{4}$ " inf.	$4\frac{1}{2}$ " inf.
8	7 " $9\frac{1}{2}$	$6\frac{3}{4}$ " 10	$6\frac{1}{2}$ " 11	6 " 13	$5\frac{1}{4}$ " 18	$4\frac{3}{4}$ " 36	4 " inf.
6	$5\frac{1}{2}$ " $6\frac{3}{4}$	$5\frac{1}{4}$ " 7	5 " $7\frac{1}{2}$	$4\frac{3}{4}$ " $8\frac{1}{4}$	$4\frac{1}{2}$ " 10	4 " 14	$3\frac{3}{4}$ " 30

Fixed focus cameras
are focused upon 25
feet.

"Inf." is the abbreviation for Infinity—meaning an infinite distance from the lens.

For Lenses commonly
used on Cameras making
pictures $1\frac{1}{2} \times 2\frac{1}{2}$.

TABLE No. V

Vest Pocket Autographic Kodak; Vest Pocket Autographic Kodak Special.

	$f/6.9$	$f/7.7 \text{ \& } 8$	$f/11$	$f/16$	$f/22$	$f/32$	$f/45$
Anastigmat	—	U.S. 4	U.S. 8	U.S. 16	U.S. 32	U.S. 64	U.S. 128
Rapid Rectilinear	—	—	No. 1	No. 2	No. 3	No. 4	—
Meniscus Achromatic	—	—	—	—	—	—	—

Distance Focused Upon	ft.	ft.	ft.	ft.	ft.	ft.	ft.
100 ft.	21 to inf.	19 to inf.	14 to inf.	11 to inf.	8 to inf.	6 to inf.	4 $\frac{1}{2}$ to inf.
*25	13 $\frac{1}{2}$ " inf.	12 " inf.	10 $\frac{1}{2}$ " inf.	8 $\frac{1}{2}$ " inf.	6 $\frac{3}{4}$ " inf.	5 " inf.	4 " inf.
15	10 " 26	9 $\frac{1}{2}$ " 37	8 $\frac{1}{2}$ " 120	7 " inf.	5 $\frac{3}{4}$ " inf.	4 $\frac{1}{2}$ " inf.	3 $\frac{1}{2}$ " inf.
10	7 $\frac{1}{2}$ " 13 $\frac{1}{2}$	7 $\frac{1}{6}$ " 16	6 $\frac{1}{2}$ " 22	5 $\frac{3}{8}$ " 46	4 $\frac{5}{8}$ " inf.	4 " inf.	3 " inf.
6	5 " 7	4 $\frac{5}{8}$ " 7 $\frac{3}{4}$	4 $\frac{1}{2}$ " 9	4 " 11	3 $\frac{3}{8}$ " 17	3 " 110	2 $\frac{3}{4}$ " inf.
4	3 $\frac{3}{8}$ " 4 $\frac{3}{8}$	3 $\frac{1}{2}$ " 5	3 $\frac{1}{2}$ " 5 $\frac{1}{2}$	3 " 6	2 $\frac{5}{8}$ " 7 $\frac{3}{8}$	2 $\frac{1}{2}$ " 11	2 $\frac{1}{4}$ " 35
3	2 $\frac{5}{8}$ " 3 $\frac{1}{4}$	2 $\frac{3}{4}$ " 3 $\frac{1}{2}$	2 $\frac{3}{8}$ " 3 $\frac{3}{8}$	2 $\frac{1}{2}$ " 4	2 $\frac{3}{8}$ " 4 $\frac{1}{2}$	2 $\frac{1}{6}$ " 5 $\frac{1}{2}$	1 $\frac{5}{8}$ " 8 $\frac{1}{2}$

*Fixed focus cameras are focused on 25'. For depth of focus refer to the depth of focus for 25' in the above table.

"Inf." is the abbreviation for Infinity—meaning an infinite distance from the lens.



About Lenses



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