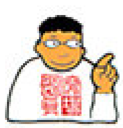
- Introduction to Single Lens Reflex Cameras -

Part 2: Lens --- A Magician of Light



An interchangeable SLR lens is large, heavy and expensive.
However, the mechanism itself is identical to that of a magnifying glass or loupe, everyday objects not usually associated with SLRs.
What is the difference between these optical products ?
Is it possible to use a magnifying glass to take a picture ?
To answer these simple questions, I would like to discuss camera lenses in depth and showcase some unique types of SLR lenses.

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[3. Unique Lenses]

[3.1. Teleconverter] / [3.2. Reflex Lens] / [3.3. Fisheye Lens] / [3.4. PC Lens]

1. The Basics

1.1. Differences between a magnifying glass (loupe) and a camera lens

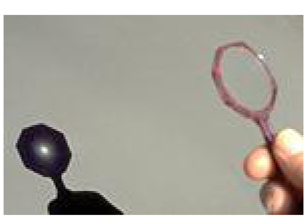
The word "lens" traces its roots to the contents of this can, lentil beans, because the shape of a double-convex lens resembles the shape of these beans.

(**Photo 1** : Right) A can of lentil beans [Made in Italy]

I'm sure many of us have tried burning paper using a magnifying glass (loupe) to concentrate sunlight in one precise spot.
In photography, that spot is called the focal point, and the distance between the lens and the spot is called the focal length.
If weather permits, get a magnifying glass (loupe) and try the following simple experiment, which will raise many interesting points for consideration.

Q. "Collecting" sunlight with a magnifying glass.
The picture here (**Photo 2.a** : Right) shows sunlight that is "out-of-focus."
Even though the focus is precise, the outline of the sun is nevertheless clear and circular. Why?

A. Because the lens of the magnifying glass is circular.
Cover the lens with black paper with a square or a triangle cut in the center.
How does this configuration make the sunlight "out-of-focus"?



Q. "Focal point" is the spot where the sunlight collects.
The distance between the lens and this spot is the focal length.
You can measure this distance with a ruler to determine focal length.

If you examine the sunlight closely, youŽÕll see that it collects in the shape of a circle, not a "point" or "dot." (**Photo 2.b** : Left). Why?

A. Because the sun has "size."
The sun is 1,400,000 km in diameter and is 150,000,000 km away from the Earth, and appears at an angle of 32 minutes (which is almost one-half a degree).
Put simply, the light appears circular because the sun is circular, not a "point" or "dot."

Q. By angling the magnifying glass, the shape of the focus point becomes distorted (**Photo 2.c**: Right).
Why does this happen ?

A. The magnifying glass(loupe) being used is not of high quality. Camera lenses and expensive loupes do not experience this kind of distortion, known as an aberration.

Next, we'll explain magnification of loupe, focal length and aberration.

• Magnification of a loupe
A loupe's magnification usually indicated as 4x, 8x and multiples thereof. This is known as the standard magnification ratio, which is the ratio of how large an object appears when viewed from a distance of 25cm (about 10in.). In formula, let the standard magnification ratio be M and the focal length be f (in millimeters). This yields the equation M = 250 / f (mm), which means that a 4 x-magnification loupe is a convex lens with a focal length of 75mm .
A typical magnifying glass(loupe) has a focal length of about 150 ~ 200 mm, so its standard magnification ratio is less than 2 x. However, magnifying glasses are not always used to produce an enlarged image : they are used for rectifying far-sightedness or presbyope, and for people who have a hard time focusing on objects that are close to them.

To illustrate, try drawing a loupe closer to your eye. You can observe an object at the largest magnification (standard magnification ratio + 1 x).

(**Photo 3** : Left) Uses for magnifying glasses (loupes).
By drawing it closer to your eye, magnification will increase.

• Focal Length
Unlike magnifying glasses and loupes, a camera lens contains many lens elements, and it is therefore difficult to determine base focal length.
The base is called the lens' principle point.
This is a complex concept; for our purposes, think of the principle point as the area around the center of the camera lens.
There are, however, two exceptions.

A. **Retrofocus type**

Most wideangle lenses for SLR cameras are Retrofocus types.
The principle point of theses lenses is located in the back portion of the lens.
A retrofocus lens is constructed so it will not collide with the reflex mirror of an SLR camera, even in lenses with short focal lengths.

B. **Telephoto type**

The principle point is located in the front portion of the lens.
This shortens the length of the bellows, and is useful for shooting telephoto pictures with large-format film.

The "35" of 35 (135) mm-format film represents the width of the film, which is 35mm. It has nothing to do with focal length.

(**Photo 4: Left**) Adjusting focal point with a camera lens. Notice how much sharper it is than the magnifying glass.
If you see carefully, you'll be able to see buildings and light poles.
However, it is difficult to determine the optimal focal length when using thick lens, such as camera lens.

• Aberration

Ideally, there are three ways an image should appear when enlarging or projecting an object with a camera lens:

- As a succinct "point" appearing as a "dot."
- Focus should be on a flat surface vertical to the optical axis.
- Identical to the original.

In practice, obtaining such a perfect image is impossible, which in turn means that a perfect lens can never be created. **Aberration** is at the heart of this and can be explained with a little mathematics. There are five (5) basic types of aberrations : **spherical aberration**, **coma**, **astigmatism**, **curvature of image**, and **image distortion** (known as a three-dimensional aberration).

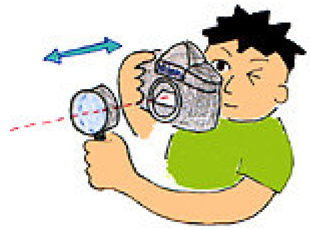
An aberration caused by a prism, in which light is broken up into spectral colors, is called a **chromatic aberration**.

(**Photo 5** : Right) Enlarging a calendar date with a convex lens. You can see that the image is distorted around the peripherals. Also notice the coloration caused by "**chromatic aberration**".

1.2. Taking a picture using a magnifying glass (loupe)

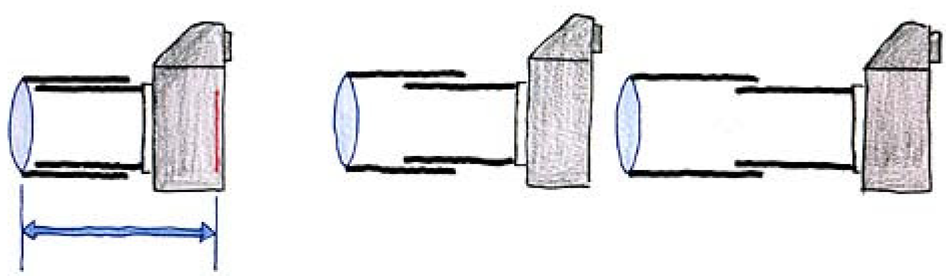
Now, let's try a simple experiment.
Mount an SLR camera without a lens on a tripod. Holding a magnifying glass in your right hand, center its optical axis with the mirror of the SLR. Determine the correct focus by moving the magnifying glass forward or backward.
Next, compare this with the focal length which was previously set on your camera. By doing this, you will discover a simple but important relationship.
To set the focus when an image is at "infinity" (far from the camera), make the distance between the magnifying glass and the film surface the same as the focal length of the magnifying glass. To focus on a nearby object, move the magnifying glass away from the camera.
If there isn't strong light entering the camera, you can take a picture using the magnifying glass. Try it just to study the results. [If your camera has stop-down metering and aperture-priority auto exposure mode, then you can take an AE (auto-exposure) picture.]

(**Fig. 1**) Taking a picture with a magnifying glass
Follow the instructions above to take a picture using a magnifying glass.



I think you can guess from here on.
If you have a cylinder that shuts out unwanted light (a lens barrel or lens housing), you can take a picture using a magnifying glass.

Make a hole in the bodycap and get enough thick paper or plastic to cover it.
The length of the lens barrel should be congruent to the focal length of the magnifying glass (as seen in the blue arrows in the left picture of Fig. 2 at the bottom).
If the barrel is elastic, you can take pictures in a variety of situations.
If your camera has stop-down metering and aperture-priority auto exposure mode, then you can take an AE picture.



(Photo 6.a)

A hole in a Body Cap **BF-1A**.
This is where the magnifying glass will be mounted.

(Photo 6.b)

Make an elastic lens barrel and attach a magnifying glass and the prepared body cap.
Consider the length of the lens barrel when making it.

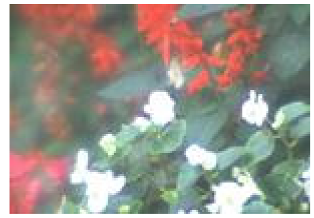
(Photo 6.c)

Completed apparatus.
It's a simple lens, but it can take aperture-prioritized AE picture using stop-down metering.

(**Photo 7.a ~ 7.c**) Pictures taken using a magnifying glass assembly as seen in **Photo 6.c**. Because the photos have a wide aberration range, they appear blurred.

(Photo 7.a)
Infinity

(Photo 7.b)
Medium proximity (about 5 meters)



(Photo 7.c)
Close proximity (about 1 meter)

2. What Happens When Focal Length Changes ?

I can classify the lenses of a 35mm (135) -format camera into four (4) types.
There are three(3) types of lenses with fixed focal length :

- **Normal lens** : Focal length of around 50mm
- **Telephoto lens** : Focal length longer than a normal lens (long-focus lens with a telephoto ratio of less than 1.0)
- **Wideangle lens** : Focal length shorter than a normal lens

An example of a lens with variable focal length (vari-focal lens):

- **Zoom lens** : Can continuously change the focal length, but the focal point remains unchanged

It is difficult to say "which lens is best", because it depends on your subject and how you want the picture to look.
Naturally, focal length will affect how the picture turns out. I hope you have fun with these different types of lenses.

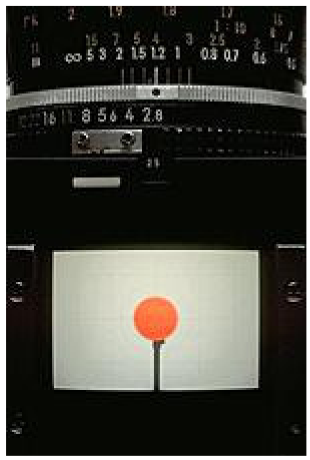
Okay, let's talk about the versatility in taking pictures with different focal length.

2.1. Focal length and size of the image

The longer the lens's focal length, the larger an object will appear

on the film surface.
But how large ? It is proportional to the focal length (except with close-ups and when using a fisheye lens).
For example, when using a telephoto lens with a focal length of about 100 ~ 105mm, you can photograph an object about twice as large as a picture taken with a 50mm normal lens.
With a 200mm lens, a picture will be 4 times larger than one taken with a 50mm normal lens.
The relationship is obvious.

(Photo 8.a)
28mm



(Photo 8.b)
55mm

(Photo 8.c)
105mm

(Photo 8.a ~ 8.c) Examples of taking pictures of the same object from the same distance with increasing focal lengths.
You can see that as focal length increases, the size of the image on the film increases.
(The image is appearing large in the camera's focusing screen, as shown in **Photo 8.a to 8.c**)

The zoom ratio of a zoom lens is the largest focal length value divided by the smallest value.
For example, 35~70mm zoom lens has a zoom ratio of 70 / 35, or 2.
This means that this zoom lens can enlarge an image two times (or halve the size depending on which focal length you're using to calculate).

2. 2. Focal length and picture angle

As stated above, a subject will appear larger on the film surface as the focal length increases (as with telephoto lenses). Another way

of saying this is that as focal length increases, the range of the image appearing will narrow.
Conversely, a shorter the focal length allows photos (as with wideangle lenses), to be taken in a wider range. You should be especially careful as the focal length decreases, because a few millimeters added or subtracted will make a big difference in the picture angle.

A lens's picture angle indicated in its manual or catalogue represents the area of the image appearing on 35 mm (135)-format film. The image will appear within a diagonal line of 43mm, which means the film size is 24 x 36mm.

Focal Length (mm)	**20**	**24**	**28**	**35**	**50**	**85**	**105**	**135**	**180**	**200**
Diagonal Picture Angle	94°	84°	74°	62°	46°	28° 30'	23° 20'	18°	13° 40'	12° 20'
Horizontal Picture Angle	83°	74°	64°	53°	39°	23° 50'	19° 30'	15°	11° 30'	10° 20'
Vertical Picture Angle	61°	53°	45°	37°	26°	16°	13°	10°	7° 40'	6° 50'

The picture angle of a 50mm lens is 46 degrees, about 50 percent of 90 degrees.
This is called "Normal" for 35mm (135)-format film.
A focal length of 22mm can encompass 90 degrees.
The focal length value and picture angle is inversely proportional (the smaller the focal length, the wider the picture angle).

(**Photo 9.a ~ 9.c**) Pictures of different focal lengths, taken the same distance from the object.
Notice the difference in the size of the object and the picture area depending on the focal length.

(Photo 9.a)	(Photo 9.b)	(Photo 9.c)
35mm	**80mm**	**200mm**
Wide	**« --»**	**Narrow**
Small	**« --»**	**Big**

2. 3. Focal length and perspective Focal length and perspective

If picture angle changes with focal length, then a lens with a wider picture angle lets you take smaller pictures of a distant object. Just the opposite, a telephoto lens lets you take pictures of both close and distant objects with only a slight difference in size.

A wideangle lens exaggerates perspective, thus the image appears slightly distorted.
On the other hand, when using a telephoto lens, there is not much difference in perspective between close and distant objects.
However, the "shape" of the object is very accurate, just like a blueprint.
This is one of the reasons why telephoto lenses are used when taking pictures for catalogs.
You can illustrate this difference by moving toward (or away from) an object while using a wideangle lens, though this is of course not how wideangle lenses are meant to be used.
Zoom lenses have become very popular, but changing your physical distance from the object will make the picture image very different.
This method is much cheaper than purchasing expensive lenses and will also allow you to take unique pictures.

(**Photo 10.a ~ 10.c**) Pictures taken at different distances from a subject with the film surface (shooting distance) adjusted so the size of the subject's face stays the same.

These pictures were taken with wideangle, normal and telephoto lenses.
Depending on the focal length, distance between the image and its perspective becomes very different.
The image of the picture changes quite significantly.

(Photo 10.a)
35mm
Near
Exaggerated

(Photo 10.b)
80mm
« --»
« --»

(Photo 10.c)
200mm
Far
Accurate

3.1. Unique Lenses

There are many common lenses that allow you to take interesting and creative pictures.
You might have trouble using them at first, but they can be used for most Nikon SLR cameras.
Using these lenses, anybody can take unique pictures.

NOTE : Some lenses and camera bodies do not go together.
Please check the appropriate catalogue or manual.)

3. 1. Teleconverter

The teleconverter mentioned here can be attached between the main lens (master lens) and the camera body.
By simply attaching this conversion lens, focal length increases by 1.4 times or 2 times (in the case of the current *Nikon* camera product lineup).
Because this type is attached to the rear part of the master lens, it is sometimes called a "rear converter".
(**NOTE** : Some lenses and camera bodies do not go together.
Please check the appropriate catalogue or manual.)

A teleconverter has a convex refraction and cannot form an image by itself; the lens itself does not have a focal length. The camera's

AE function can be used.

Its characteristics are listed below.

- The actual aperture value (f-number) is darker. With a 1.4 x model, it becomes one step darker. With a 2 x model, it becomes two steps darker.
- The main lens's depth of field indicator can be used.
- The shortest shooting distance remains the same. This means that it can take either 1.4 x or 2 x enlarged pictures.

3. 2. Reflex Lens

This is a telephoto lens in which, by replacing most of the dioptrical sections with one big and one small concave mirror, the lens barrel becomes shorter, lighter and more compact.
It is often used in astronomical telescopes.
The reflex lens is an optical lens with a combination of two(2) desirable features.
It adopts catoptrics, in which the concave mirror does not cause chromatic aberration, and it adopts dioptrics, which are advantageous for compensation of spherical aberration.
Unlike a dioptrical lens, it is thin, small and light, and can be hand-held.
It is ideal for taking pictures in sunny conditions using a super-sensitive film.
Its characteristics are as follows :

- In Nikon's current product lineup, the **Reflex Nikkor 500mm f/8**and other reflex telephoto lenses have a fixed aperture.
  Thus, depth of field cannot be controlled. You can take AE pictures when the camera is set to aperture-priority AE mode.
  If a picture becomes over-exposed because the SLR camera body's shutter speed cannot react, then attach an ND (Neutral Density) filter.
  Or, you might have to change to a film with lower sensitivity.
- When a point is blurred, it becomes donut-shaped. When a line is blurred, it becomes a parallel line.
- The shortest shooting distance for the **Reflex Nikkor 500mm f/8** is 1.5 meters. It is ideal for close-ups.

(**Photo 11.a ~ 11.e**) Pictures using the **Reflex Nikkor 500mm f/8 (NEW)**

(Photo 11.a.)

Picture using a 50mm normal lens.
Can you see the heron in the center of the picture ?

(Photo 11.b.)

Picture using a 500mm f/8 lens.
The heron is now in plain sight.
The image on the film surface is about 10 times larger than when using a 50mm lens.

(Photo 11.c.)

Picture using a 500mm f/8 lens with a 2x teleconvertor.
The lens basically becomes a 1000mm f/16 lens. Camera shake might become apparent if you are using an unstable tripod.
Also, because the aperture is fixed at f/16, it may be difficult to focus.
Depending on the brightness of the object and film sensitivity, the object might blur significantly. Thus, caution is necessary when shooting.

(Photo 11.d.)

An example of a close-up taking advantage of the 1.5-meter shooting distance.
This feature is remarkably useful.

(Photo 11.e.)

A donut-shaped blur is visible in the rear of the photo, characteristic of a reflective telephoto lens.

3. 3. Fisheye Lens

A fisheye lens has a picture angle of about 180 degrees that

appears on the film surface. This type of lens is called a fisheye because most fish have 360-degree vision (180 degrees in each eye).
In the current Nikon lineup, the **Ai AF Fisheye-Nikkor 16mm f/2.8D** can capture a picture on a diagonal of 180 degrees on the film surface.

Nikon's past product lines included the **Ai Fisheye Nikkor 8mm f/2.8** that on 35mm (135)-format film could capture a picture at a picture angle of 180 degrees within a diameter of about 23mm. This lens was sometimes referred to as a circumferential fisheye lens.
There was also the **Ai Fisheye Nikkor 6mm f/2.8**, with a picture angle of **220 degrees** *!*.
This lens surpassed human capability (about 180 degrees) and, through an SLR viewfinder, could capture the image on a single photo.

In the realm of digital cameras, the Nikon **COOLPIX 900** can accommodate a front converter (the Fisheye Converter **FC-E8**), a special accessory that makes the Zoom Nikkor lens behave like a fisheye lens.
It acts like a circumferential fisheye lens of about 8mm of a 35mm (135)-format film camera.

Unlike ultrawideangle lens, a straight line which does not pass through the center of the picture is distorted.

(Photo 12.a.)

Picture using the full-frame fisheye lens **Ai AF Fisheye-Nikkor 16mm f/2.8D**.
The peripherals of the picture are distorted.

(Photo 12.b.)

Picture using the **Ai AF Fisheye-Nikkor 16mm f/2.8D**.
Most of our own visual area can be captured in a single picture.

(Photo 12.c.)

Picture using the **FC-E8** attached to the **COOLPIX 900**.
With this, it functions as a circumferential fisheye lens with a picture angle of roughly 183 degrees.

3. 4. PC Lens

"PC" stands for perspective control.
Think of it as a lens that can adjust distances.
With the **PC Nikkor 28mm f/3.5**, the lens can be shifted left or right, parallel to the film (about 11mm). Just as in large-format cameras, it is possible to "displace" — or rise and/or fall (also called "drop") --- the picture.
When taking a picture of a building, a PC lens can make all perpendicular lines appear parallel, avoid shooting obstacles, avoid image reflection, and produce a panoramic picture by connecting the pictures.

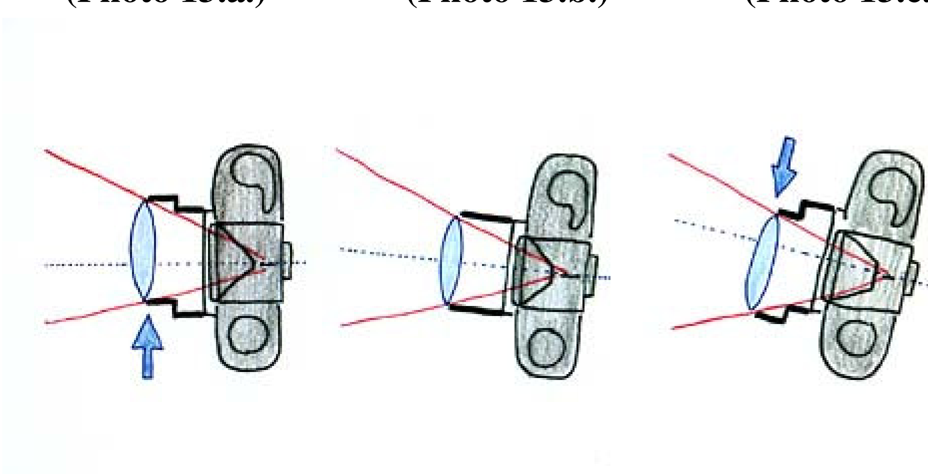
With a PC-Nikkor lens, the aperture is pre-set, which is different from normal lenses. This might take some getting use to.
Also, "displacing" will make the image a bit dark, so exposure adjustment is necessary. (**Note** :Some lenses and camera bodies do not go together. Please check the appropriate catalog or manual)

(Photo 13.a ~ 13.c) Pictures using the **PC-Nikkor 28mm f/3.5**

(Photo 13.a.)

(Photo 13.b.)

(Photo 13.c.)



Picture taken by keeping the film surface perpendicular and the lens parallel (displacing). This can make perpendicular lines appear parallel, as in a blueprint.	Picture taken without any displacing. It appears the same as when taken with a normal 28mm wideangle lens.	Picture taken by displacing in the opposite direction (falling), as in **Photo 13.a**. PC lenses can exaggerate perspective.

Note : The optical axis of a lens meets the center of the picture image on the film surface. When this does not apply, it is called "camera movement."
"Camera movement" includes the following actions :

- Displacement — or shift, rise and/or fall (also called "drop") -- which alter the standard optical axis-film surface relationship, though the lens surface (or the film surface) is shifted.
- "Swing and tilt," which alters the optical axis-film surface relationship.

To be exact, only "displacement" means "camera movement". In Japan(Nippon), the two are mixed up and is both called "camera movement".

See how wonderful these lenses are ?
If I keep on introducing specifically, there will be no end.
Therefore, let's pause right here.

In the next article (Part 3), we'll take a tour of the wonderful world of film.

Go to "Who's Afraid of SLR Camera ?" Index

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