Introduction to Photography with the Leica M-A

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To Lucie, Maël, Margot, Maxime, and Sacha

Forward

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- Bibliographic references are denoted [n] where n is the reference number. For example [23] refers to the Leica M-A instruction manual.
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Introduction to Photography with the Leica M-A

Patrick Cousot

Abstract

A short, simple, and illustrated introduction to the fundamental concepts of analog photography (with a few optional technical explanations), and their practical application with a Leica M-A.

1 The Leica M-A Camera

Leica is a camera maker company that brought to prominence the 35mm film camera in 1925 (Leica A), the rangefinder camera in 1932 (Leica II), the M-mount lenses in 1954 (Leica M3) and their digital versions since 2006 (Leica M8). The Leica M-A is a 35mm film camera that first appeared in 2014. The "A" stands for "analog".

Like all traditional Leica M cameras, the M-A camera has a viewfinder (for composition/framing, see section 13) and a rangefinder (for manual focussing, see section 23.2 and optional technical details in section 42). The exception is the Leica M EV1, launched in 2025, which has no rangefinder but an electronic viewfinder.

a

Figure 1: Leica M-A (here with a soft release button, a carry strap, and a M-mount SUMMILUX-M 1:1.4/35 ASPH lens with UV filter (see section 36) and screwed lens hood).

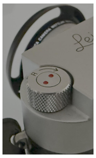
Always carry the camera while holding the strap to avoid falls.

We explain in simple terms how to use the Leica M-A (clicking on dark blue text refers to another section of the e-booklet or to Wikipedia for more detailed and scientific explanations).

Before taking a photo, a film must be loaded in the camera and a lens has to be mounted.

2 Loading a Film in the Leica M-A

- To make sure that no film is already in the camera, first move to rewind button from down to fully up



Rewind button down

Rewind button fully up

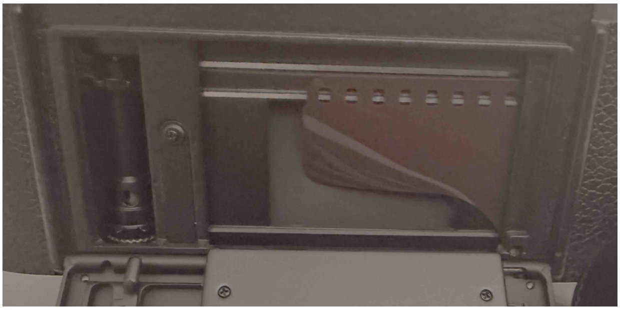
and then turn it clockwise. There should be no resistance. Otherwise, unload the film, as explained in section 5.

- Take the bottom cover of the camera off (by lifting the toggle and turning it left, anticlockwise);

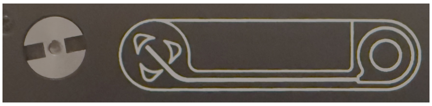
- Open the rear panel

- Insert the film cartridge into the right film holder of the camera

- Push the film left with a finger



as shown in the schema at the bottom of the camera (when the bottom cover has been taken out)



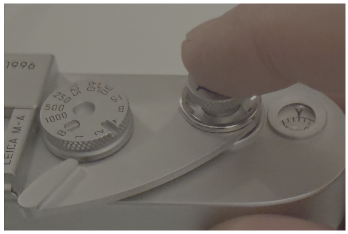
until the film leader is inserted into the take up spool

- Close back the rear panel and put back the bottom cover of the camera in position

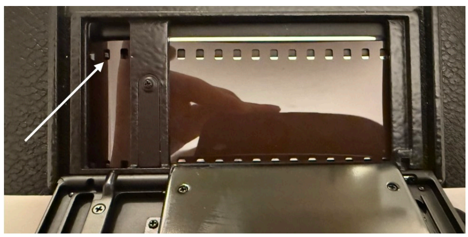
before closing with the rear toggle.

- Wind the film forward one frame using the quick wind/film advance lever

and let it come back to its rest position. Then release the shutter.



- To ensure the film is properly engaged, this first photo can be taken with the rear panel opened to make sure that the film advances correctly when pushing the film advance lever.



The film perforations are properly caught by the gears.

- Push the shutter again and cock the film advance lever two more times. The frame counter now shows 1

and the camera is ready to take a first picture.

- Finally, set up the film ISO on the back of the camera (in front of the black arrow for monochrome films and the red arrow for color films).

Monochome ISO recording

Color ISO recording

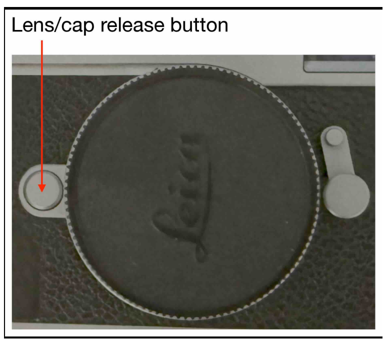
  This is a convenience to easily remember the film ISO with absolutely no effect on the camera and the photos taken.

3 Mounting a M-Lens

A lens can be mounted when a film is in the camera since the shutter is closed and will prevent light from reaching the film. The Leica M-mount allows many different lenses to be mounted on the M-A camera body.

- First remove the rear cap of the lens by turning it anti-clockwise (here a NOCTILUX-M 1:0.95/50 ASPH) to see the M-mount.

- Then remove the camera cap by maintaining the lens/cap release button pressed down and then turning the cap left.



- Then mount the lens (a SUMMARON-M 1:5.6/28mm in the example)

(by aligning the red button on the camera with the red button/mark on the lens and then turning the lens clockwise to the right until hearing a click, which is important to make sure that the lens is correctly fixed on the camera).

The lever in front of the camera also shows whether the lens is correctly mounted.

incorrectly mounted lens
(lever on the right)

well-mounted lens
(lever on the left)

- To unmount the lens, maintain the lens release button in the front of the camera pushed down and then turn the lens anti-clockwise to the left. Put back the caps/covers on the lens and the camera.

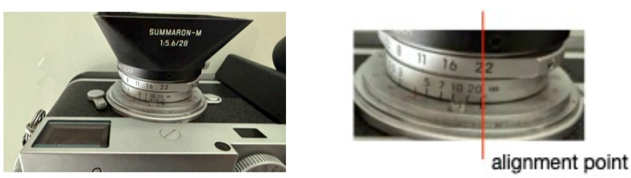
4 The First Photo With a Leica M-A

- Before taking the first photo it is necessary to set up the shutter speed on the camera, the aperture and the distance to the subject on the lens.

- The shutter speed is chosen by turning left or right the shutter speed dial on top right of the camera.

Shutter speed on 1/125 s (second)

- The lens aperture is chosen by turning left or right the aperture ring on the lens.



The lens set up at aperture f/22

- A rule of thumb (sunny 16 rule) to set up the lens aperture and shutter speed is the following

weather:		sunny	slight overcast	overcast	heavy overcast	shade
ISO	Speed			Lens aperture		
100	1/125	f/16	f/11	f/8	f/5.6	f/4
200	1/250	f/16	f/11	f/8	f/5.6	f/4
400	1/500	f/16	f/11	f/8	f/5.6	f/4

The speed is chosen once for all at about 1/ISO rounded to the closest available speed on the shutter speed dial. For example, that would be 1/100 for ISO 100 which rounded to the closest available speed is 1/125 written 125 on the shutter speed button. Then the lens aperture is chosen as a function of the weather from f/16 to f/4 for sunny to dark weather. This is very approximate and the use of a lightmeter is much more precise (see section 29).

- Turn the distance on the lens to infinity (∞, math for very large/far).
- Get the lens front cap off, if any.
- Look in the viewfinder (see figure 2) to a landscape or a distant subject.
- Press the shutter button (see figure 2). You should hear the characteristic shutter noise and the photo is taken, result at development!

  If nothing appends (there is no shutter noise), this is because the next photo is not advanced in position. In that case push the lever right, release it, and push the shutter button once again.
- There are two schools on which state to leave the camera after shooting a photo.

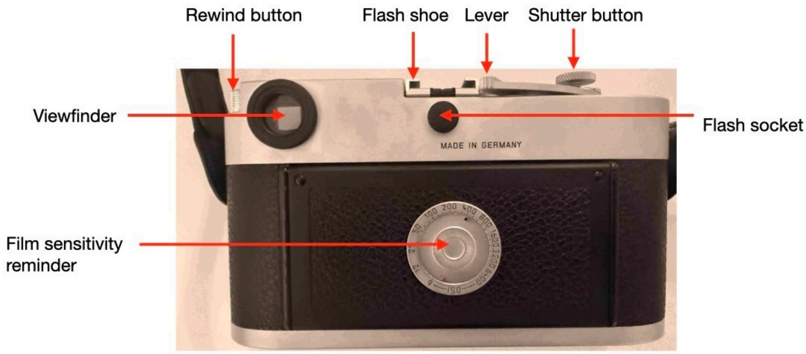


Figure 2: Back of the Leica M-A

- One can push the film advance lever right to prepare for the next photo. This ensures rapid shooting of the next photo but there is a risk to push the release button by inadvertence.
- One can do nothing after shooting a photo. The shutter is then blocked so no photo will be taken by inadvertence. But then the film advance lever must be pushed before taking the next photo, which requires a little more time.

Read what follows to understand what you need to know for your next photos! When your film is full, you have to rewind it and send it for development.

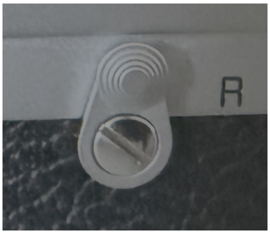
5 Rewinding the film

This last frame is reached on the film when the lever can no longer be pushed right all the way out without resistance.

The photo count is another way of knowing that the film is finished.

The film must be rewound in its cartridge and removed, as follows.

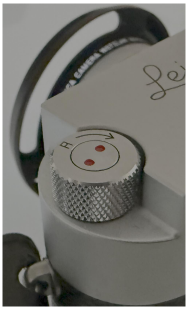
- Move the rewind release lever in front of the camera from the “off” to the “on” position marked R.



Rewinding lever off

Rewinding lever on

- Pull the rewind button from down to its maximal up position



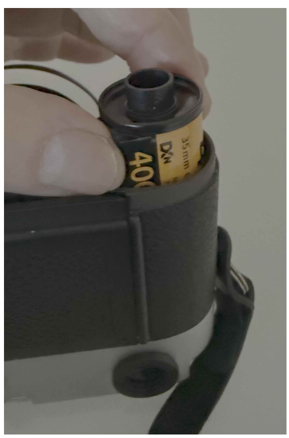
Rewind button down

Rewind button up

- Turn the rewind button clockwise, on the right, as indicated by the arrow to fully rewind the film in its cartridge. This can be a bit long but the end is clear when there is no more resistance.

- Open the bottom cover and the rear panel.

- Remove the film cartridge.



- A photographic 35 mm film processing and scanning business will develop your film to get a contact sheet/print, prints of the photos at various sizes, and scans that is digital copies of the film images at different possible resolutions.

Let us now start better understanding photography, the Leica M-A camera, and its lenses.

6 Light

Photography is the art of fixing visible light on a support. We see and the camera records light from a source (sun, artificial lightning) that reflects on objects.

Light propagates in straight line beams (think to the straight rays of the sun visible through a cloud), of course except for reflexion on a mirror and refraction, for example through a liquid.

Light has an intensity giving an impression of brightness or brilliance (in absence of clouds, the light of the moon is less intense that the light of the sun at sunrise or sunset, which is itself less intense that the light of the sun at noon).

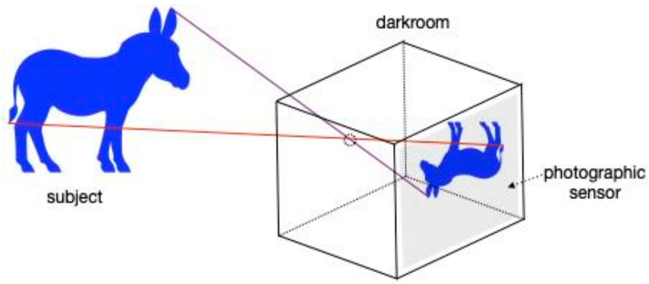
Light is also a quantity (the quantity of light received from the moon for a long time is the same as the quantity of light received from the sun during a very brief instant).

Light can be polarized by reflection on metal or water which alter how the light is transmitted and seen (for example polarization of light allows the glare-reducing effect of polarized sunglasses. Polarizers in photography annihilate light polarization, see section 40).

More scientific details on en.wikipedia.org/wiki/Light, en.wikipedia.org/wiki/Polarization_(waves), or [40].

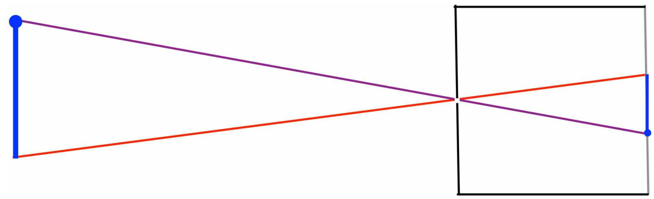
7 Darkroom

The darkroom has been known for centuries and is at the origin of photography. A darkroom is a box with a small pinhole in one face and a image sensor on the opposite face. This sensor was originally made of frosted glass or thin paper. The light beams going through the tiny pinhole reach the image sensor. Of course if the light outside the box is intense one sees nothing on the image sensor. But if the image sensor is seen in the dark (by looking at the image sensor while covered by a black cover), one can see an inverted image of the subject (flipped horizontally and vertically, that is, turned 180°).



This is because a ray of light from the top left of the subject goes through the pinhole and arrives at the bottom right of the image sensor. The same way, a ray of light from the bottom right of the subject goes through the pinhole and arrives at the top left of the image sensor. Of course cameras flip the image to see it right side up on the viewfinder and screen.

Instead of reasoning in three dimensions, one can use a simpler representation of the darkroom in two dimensions, valid in the two horizontal and vertical planes, as follows.



Originally artists painted directly over the frosted glass or thin paper serving as image sensor to reproduce the subject. Nowadays some artists like Arnulf Rainer and Philippe Cognée, use a similar idea and paint over photographs.

Here is an improvised darkroom made of a cardboard carton with a pinhole in it and a image sensor made of plant-based plastic frosted with a mirror fine sandpaper of grit size 1000. The photo of the sensor under a black sheet shows that the luminous cone is inverted.



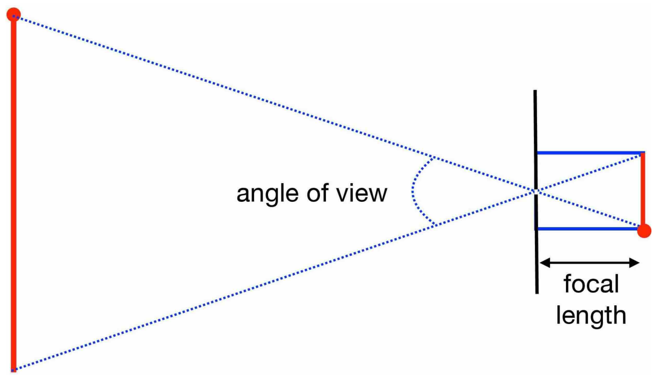
The history of photography [44] is a long search of (sometimes dangerous) chemicals able to capture the light on the image sensor of the darkroom and then fix it using a developer and then a fixer, to be able to see the photo in plain light without further modifications by exposure of the photo to light. Film photography appeared in the 1900's while digital photography appeared in the 1990's, replacing film by a digital image sensor.

8 Lenses of Different Focal Lengths

The darkroom also allows us to understand why a camera like the M-A has several lenses (objectives) of different "focal lenghts" 18 mm (millimeters), 21 mm, 24 mm, 28 mm, 35 mm, 50 mm, 75 mm, 90 mm, and 135 mm, some with adjustable focal lengths 16-18-21 mm and the older 28-35-50 mm. Some vintage focal lenses such as the Leica Summicron-C 40mm, the Konica (M-Hexagon 21-35, 28, 90 mm lenses), or the french Boyer f. Leica M 2,8/45mm Topaz, are no longer produced (the Établissements Boyer founded in 1895 disappeared in the '70s). Light Lens Lab produces copies of old lenses (28, 35, 50 mm). Other companies also produce M-mount lenses such as 7Artisans (28, 35, 75 mm), Lomography (17 mm), Meyer-Optik Görlitz (58 mm), Voigtländer (10 mm, 15 mm, 40mm), TTArtisan (35, 50, 100 mm), and Zeiss (15, 21, 25, 28, 35, 50 mm).

9 Definition of the Focal Length

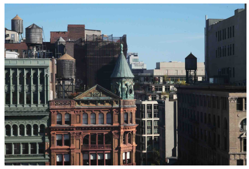
The focal length is the depth of the darkroom. It determines the angle of view and the magnification of a lens.



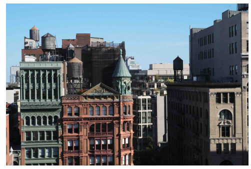
The larger the focal length is, the smaller the (horizontal and vertical) angle of view and the larger the magnification are.

This is clear on the following pictures all taken from the same shooting point and centered on the copper-covered (green) cupola of the former MSI (Manhattan Savings Institution) building in New York, now called the Bleecker Tower.

135mm



90mm

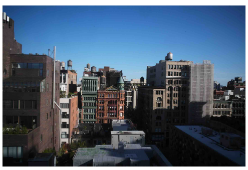


75mm

50mm

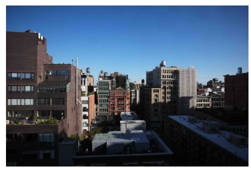
40mm

35mm

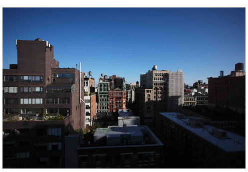


28mm

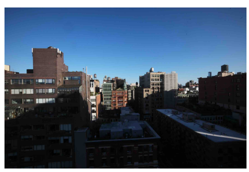
24mm



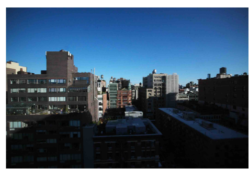
21mm



18mm



16mm

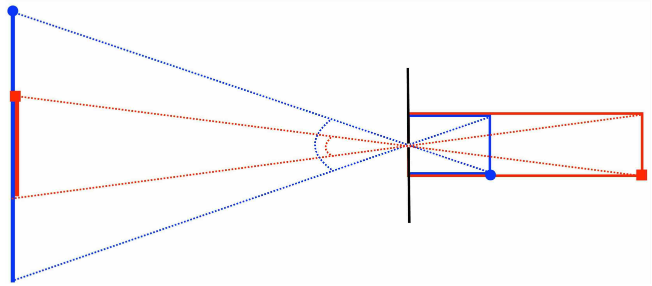


15mm

Observe the water tank (in the background on top right of the picture) appearing proportionally smaller than the cupola with small focal lengths. Let us explain why.

10 Comparing Lenses with Different Focal Lengths

Different focal lengths correspond to different depths of the darkroom box.



The two darkrooms, the small in blue and the large in red, have exactly the same image sensor size in their back but different depths, that is, focal lengths. The blue darkroom has a small focal length and records a large part of the subject (in blue). The red darkroom has a large focal length and records a small part of the subject (in red).

Notice that because the image sensors of the two darkrooms are of the same size, the red darkroom with large focal length has a smaller angle of view and can record more details of the visible subject part thanks to a larger magnification. On the contrary, the blue darkroom with smaller focal length has a larger angle of view but can record less details of the subject because of the smaller magnification.

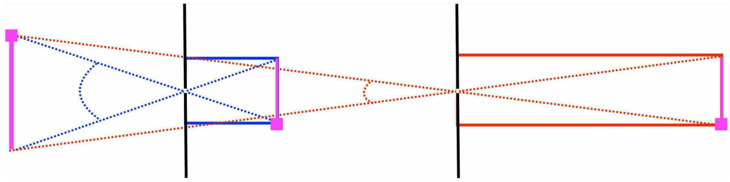
When choosing a lens, its focal length determines which part of the subject will be captured (as determined by the angle of view). This part of the subject recorded by the camera is called the "frame". This frame is visible in the viewfinder and on the screen (see section 13).

Spatial telescopes have huge focal lengths such as 57.6 meters (189 ft) for the Hubble Space Telescope and 131.4 meters (431 ft) for the James Webb Space Telescope (JWST). Photo lenses have much shorter focal lenses, typically between 10 mm and 800 mm,

11 Most Common Focal Lengths of Lenses

The most common Leica M lenses have focal lengths of 28, 35, or 50 mm. The 28 mm, with large angle of view (approximately 75 degrees horizontally), is typically used for a landscape, the 35 mm with a smaller angle of view (54 degrees) is better fitted for a group of persons, while the 50 mm with even smaller angle of view (47 degrees) will be used for an individual (although, obviously, these lenses can be used in all circumstances but produce different photos).

To take a picture of a subject of a given size with a lens of smaller angle of view, one can get farther from the subject. Symmetrically, to take a picture of a subject of a given size with a lens of larger angle of view, one can get closer from the subject.



In both cases the subject will be captured with exactly the same size on the image sensor.

But the pictures will be different! For example[1], The

[1]The pictures have been taken with the Leica LUX app on an

28mm 50mm 120mm

Figure 3: Perspective distortion

background appears farther for lenses of small focal lengths and closer with lenses of larger focal lengths, the 50 mm being very similar to the human eye. Notice also that the green glass[2] in the background is much more blurry with the 120 mm that it is with the 28 mm. The explanation is given in section 24 (depth of field).

12 Perspective Distortion

The backgrounds in the pictures of figure 3 look quite different because of the different perspective distortions, that is, what is in front and behind the subject is different on the three pictures.

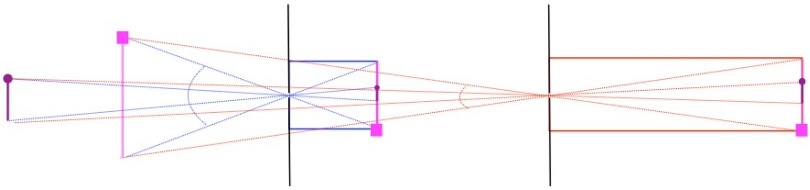
For example with a 28 mm, what is behind the subject looks very far since it will be small. With 50 mm what is behind the subject will be larger and look closer to what we see with human eyes. With the 120 mm focal length, the

iPhone, there is no Leica 120 mm M-mount lens.

[2]Couleur menthe à l'eau, Eddy Mitchell.

background is larger so looks closer.

This perspective distortion becomes clear on the following schema.



The subject (in magenta) appears to be of the same size on the image sensor of both darkrooms. But the purple object in a distance behind the subject is smaller on the image sensor of the blue camera with short focal length and larger on the image sensor of the red camera with longer focal length.

The further is an object, the smaller it looks like. Therefore, in the picture of the blue camera the brown object will look farther (since it is smaller) and it will look closer on the red camera (since it is larger).

It follows that the three 28 mm, 35 mm, and 50 mm lenses can all be used to take pictures of the subject at a given size (provided enough space is available for the photographer to move farther or closer to the subject) but, unless there is no distant background, the three pictures will look quite different.

13 Viewfinder

In darkrooms the inverted picture appears directly on the translucent sensor. In Leica M film cameras, the picture (in fact the inverted image straighten) can be seen through the viewfinder to anticipate what will appear in the pictures taken by the camera. In film photography, the photographer cannot immediately see the result and has to wait a few days until development of the photographic film in an amateur darkroom or a specialized commercial laboratory (which usually also provides a digitalization of the photos).

The viewfinder shows a view of the subject which is different from that recorded on the film through the lens (putting a hand or a cap in front of the lens leaves the viewfinder unchanged). This is because the image in the viewfinder comes from the viewfinder window in front of the camera (see figure 4). If the camera is equipped with a lens,

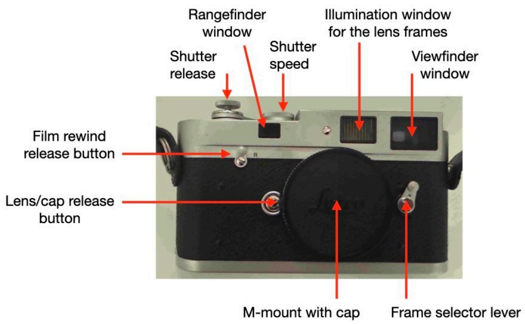


Figure 4: Front of the Leica M-A camera (with no lens)

putting an hand on the lens (or its cap) does not change what is seen in the viewfinder window. This shows that the viewfinder and the image though the lens are independent.

In particular if a cap is forgotten on the lens, this is not visible through the viewfinder.

The viewfinder view is the same for all lenses and the photo is shown in the frame in the viewfinder corresponding to the mounted lens. So the viewfinder shows the photo in its context.

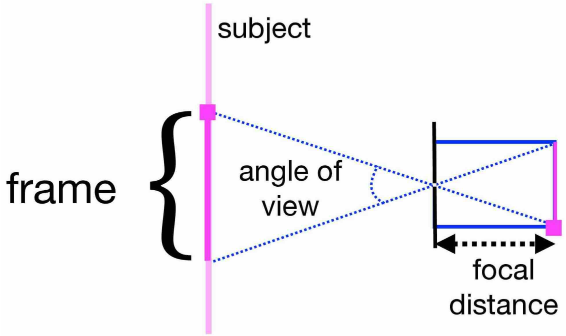
The image frame in the viewfinder with a SUMMILUX-M-1:1.4/50 mm lens

The Leica M-A selects automatically the appropriate frame for 28, 35, 50, 75, 90, and 135 mm lenses.

Finally, note that observing the sun through the viewfinder, in particular during eclipses, can damage the eyes.

14 Frame

The frame is the part of the subject reflected on the film in the camera. Only this frame part of the subject will appear on the photo.



The frame depends on the focal length of the lens. This frame can be viewed as a rectangle in the Leica M-A viewfinder when the lens is mounted (see figure 5). Only the part of the view inside the frame will appear on the photo.

Moving the Frame selector lever

Frame selector lever

(on the right of the lens when facing the camera) will show six different possibilities. Other ones can be seen using external viewfinders to be fixed on the accessory shoe.

When fixing the lens, the current frame is shown in the viewfinder. Moving the Frame selector lever shows two other possible frames, either 35 mm + 135 mm, 28 mm + 90 mm, or 50 mm + 75 mm. These two frames are represented as two rectangles, as seen on figure 5. The lens frame will be selected mechanically for 28, 35, 50, 75, 90, and 135 mm lenses (but not for other focal lengths such as the legacy SUMMICRON-C 40mm f/2). (By the way, the little white rectangle in the

Figure 5: Viewfinder frames

middle, shows what is seen through the rangefinder window (see figure 4) in superposition of what is seen through the viewfinder window. This is used for manual focussing, as explained later in section 23.2.)

If the frame produced by a lens is not satisfactory, moving the frame selector will show which lens provides the desired frame.

The illumination window on figure 4 is used to ensure the luminosity of the bright lines.

15 Framing With External Viewfinders

For other focal lenses, external viewfinders, to be mounted on the accessory shoe, provide the corresponding frame. Here are a few examples.

18mm lens and viewfinder

21mm lens and viewfinder

24mm lens and viewfinder

16-18-21mm lens and
universal wide-angle viewfinder

(the lens is equipped with a 67 mm UV filter (see section 36) with an 49-67 mm adapter since a smaller one creates vignetting (see section 34) at 16 mm).

These external viewfinders are for framing only. Focussing must still be done with the camera viewfinder.

16 Camera

A camera is a darkroom with a image sensor capturing light like a metal plaque covered by silver salts darkening with light (which yields a negative). The darkroom image sensor was originally prepared by the photographer in the dark and then covered to be protected from light. The pinhole of the darkroom is closed, the image sensor is introduced in the back of the darkroom and uncovered. It is now sensitive to light. The photographer then opens the pinhole for long enough for the image sensor to capture enough light. This time is called the “exposure time”. In the early days of photography it was hours, later seconds, and nowadays can be a millisecond on the Leica M-A.

Like the first Leica cameras, the Leica M-A uses photographic films.

17 Exposure Time (or Shutter Speed)

Originally, the exposure time was very long, a few hours, since the image sensor was not very sensitive to light. Photography was for immobile subjects only, such as landscapes. A person traversing the landscape would not appear on the photo since it did not produce a large enough quantity of light to impress the image sensor. Over time, sensitivity of image sensors improved and it became possible to take pictures of persons, provided they did not move for a few dozen of seconds. Photographers used supports of the head and body to prevent movements so that the photographed persons often looked tense, rigid, and cramped!

On the Leica M-A, the exposure time (or shutter speed) can be chosen thanks to the shutter speed dial on top right of the camera.

The shutter speed dial can be turned left or right and set to be 1/1000 s (second), 1/500 s, 1/250 s, 1/125 s, 1/60 s, a red lightning ↯ (1/50 s) for photos taken with a flash, 1/30 s, 1/15 s, 1/8 s, 1/4 s, 1/2 s, 1 s. There is also a `B` meaning that the exposure takes place as long as the shutter button remains pressed down. Note that there are *no* other intermediate speed values.

18 Camera Stand

Beyond 1/250 s to 1/60 s, the photographer will possibly slightly move the camera and the photo will be blurry. A solution is to use a monopod, a tripod or minipod,

tripod

minipod

and even a mechanical shutter release cable to avoid any movement of the camera on the tripod when pressing the trigger.

The shutter release cable has a wheel to block it in down position for the B long exposure time.

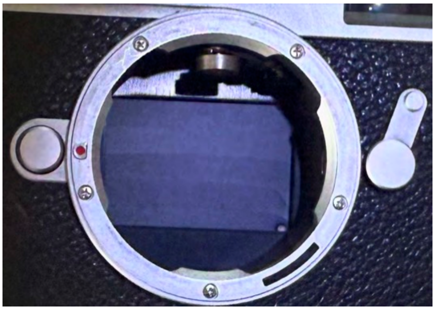
19 Shutter Speed

The shutter is the physical device on the camera that opens and closes to control the exposure time of the film as determined by the shutter speed dial on top right of the camera (that *cannot* be moved by half increments).

The faster (respectively slower) is the shutter speed the smaller (resp. larger) is the exposure time so less (resp. more) light touches the camera electronic sensor.

The exposure time is a time measured in seconds. Calling it shutter speed is somewhat a confusing misunderstanding, since a speed is measured in meters per second (m/s or fractions of these). But obviously, the faster the shutter moves (in m/s), the shorter the exposure time (in s). Calling the shutter speed the exposure time avoids the confusion.

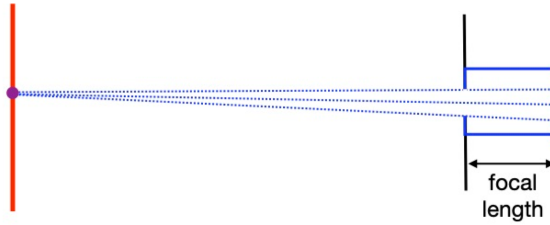
The shutter can be seen in closed position on a camera with no lense.



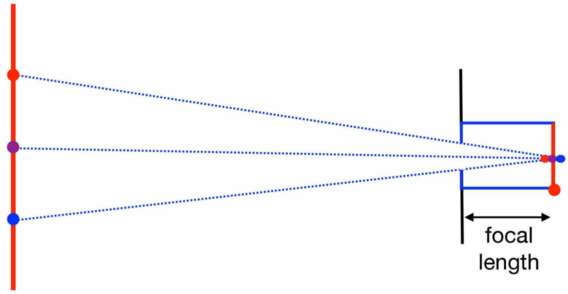
The mechanical shutter consists of light metal blades moving very quickly (in up to 1/1000 s). The shutter is very fragile and should not be touched or blown on (with one's breath or a rubber dust blower ball).

20 Lenses

An obvious solution for a darkroom to capture more light is to have a larger hole. But then a point of the subject will send light rays to different points of the image sensor.

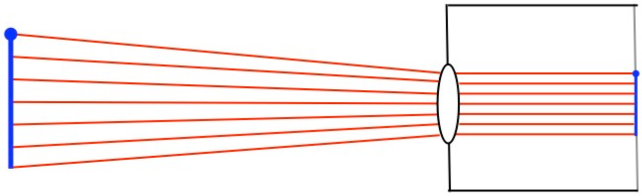


Symmetrically, a point of the image sensor will receive light from different points of the subject.

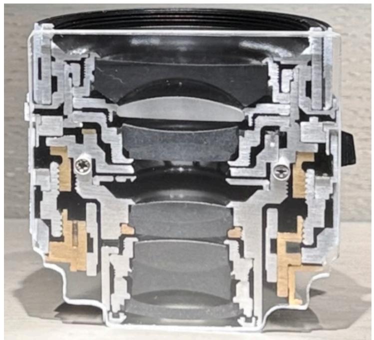


The result is that the photo will be blurry.

To allow a larger hole in a darkroom without blurring the image sensor, photographers invented lenses (that they also call objectives or glasses in slang). Ideally, a lens would project exactly the subject in reduced size on the image sensor.



In practice it is impossible to achieve this ideal goal [40, section 4.3.1, page 50] and lenses have a much more complicated design, always with some limitations [16].



(courtesy Leica Store, New York)

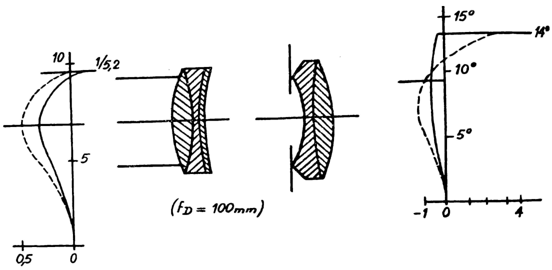


Fig. 225.- Objectif "Dialyt" de Petzval

Petzval lens [16, page 542]

There are usually several lenses in the lens[3] and some mechanism to move them within the lens for focussing, as well as a second mechanism, called a diaphragm, to determine the aperture to modify the size of the hole through which the light beams reach the image sensor, so called entrance pupil (as well as a third related one for the rangefinder, see sections 23.2 and 42).

[3]In french the lenses inside the lens are “lentilles” inside the “objectif” without ambiguity. Photographic objective is rarely used by photographers in English.

21 Aperture

Lenses have an adjustable iris diaphragm allowing for different apertures with large holes (called entrance pupil) having small numbers while small holes/entrance pupils have large numbers. Typical apertures are $f/\ 0.95$, $f/\ 1.4$, $f/\ 2$, $f/\ 2.8$, $f/\ 4$, $f/\ 5.6$, $f/\ 8$, $f/\ 11$, $f/\ 16$, $f/\ 22$. Small f-numbers (also called focal ratio, f-ratio, or f-stop) correspond to large apertures through which a large quantity of light goes through while large f-numbers correspond to small apertures through which a small quantity of light goes through. The desired aperture is chosen by turning the focus ring marked with these f-numbers. Looking through the lens clearly shows the various apertures (which exact size depends on the lens), see figure 6.

A lens with a small f-number is called fast because when wide opened it captures a lot of light so that the exposure time can be small (or shutter speed very fast). The fastest Leica lens is the NOCTILUX-M 1:f/0.95 50mm ASPH (which first appeared in 2008).

22 Leica M-mount Lenses Designation

Leica M-mount lenses are designated by esoteric names, often of latin origin, depending on the maximal aperture of the lens:

- Noctilux: maximal apertures of $f/\ 0.95$ or $f/\ 1.0$ or $f/\ 1.2$ or $f/\ 1.25$;
- Summilux: maximal apertures of $f/\ 1.4$, $f/\ 1.5$ or occasionally $f/\ 1.7$;

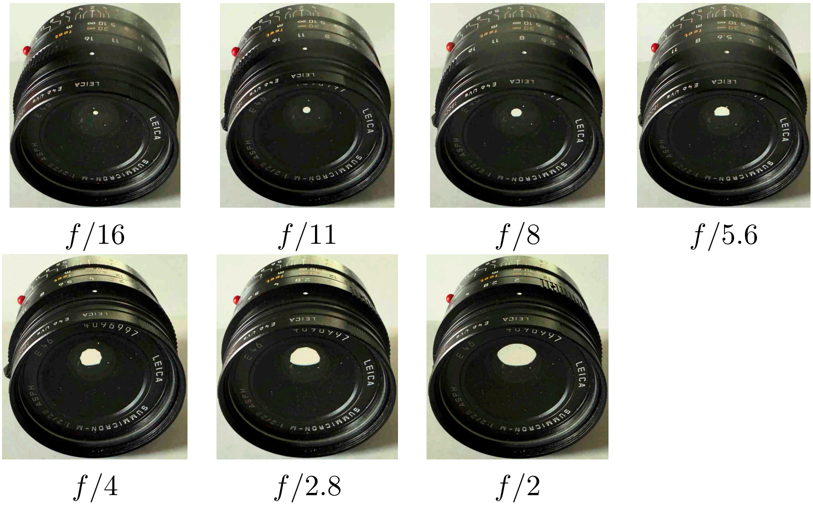


Figure 6: Entrance pupil of the SUMMICRON-M 1:2/28 ASPH lens with UV filter and no hood nor rear cap at apertures f / 16, f / 11, f / 8, f / 5.6, f / 4, f / 2.8 and f / 2. Half increments are also possible but not shown.

- Summicron: maximal apertures of f / 2;
- Elmarit: maximum aperture of f / 2.8;
- Summaron: maximum aperture of f / 2.8 or f / 3.5 or f/5.6;
- Elmar: maximum aperture of f / 3.8 or f / 4 (Tri-Elmar is for a lens offering three different focal lengths);

This name can be preceded by

- APO: aprochromatic lens enforcing all colors to focus on the sensor at the same distances from a lens;

and the designation can be followed by

- ASPH: aspherical lens to reduce optical abberations.

The name is followed by 1:f/$n.n$ where f / $n.n$ is the maximum aperture (with minimal f-number)[4] and then the focal length (in millimeters mm).

Lenses are also marked E*dd*, where *dd* is a number indicating the diameter in millimeters of the filters that can be screwed in front of the lens. For example, the APO-SUMMICRON-M 1:2/90 ASPH lens is marked E55.

Other terms and abbreviations related to Leica lenses are explained on the Understanding Leica Lenses page on Leica web site.

23 Focussing

Ideally whatever is the distance of the subject to the lens, the subject should appear sharp on the photo. Unfortunately, this is not possible in practice. Lenses must be focussed on the subject for this subject to appear clear, sharp, in focus on the photo.

On Leica M cameras, focussing is manual. A particular case is when the subject is far enough (usually more than 15/20 m), in which case the distance is set to infinity, marked ∞ on the lens.

[4]The "1:" prefix in Leica M lens designations signifies a division. For example, "1:2/50" represents a ratio indicating the relationship between the lens's focal length and its maximum aperture diameter. So, "1:2/50" signifies a 50mm lens with a maximum aperture diameter that is half of its focal length (50mm / 2 = 25mm). This translates to a maximal aperture of f / 2. More details in section 32.4.

Taking pictures of landscapes is always easy since focussing is trivially set to ∞! Otherwise, the photographer must be set manually to the distance to the subject.

The focussing distance in photography is measured from the camera's film plane to the subject, not from the front of the lens. This sensor plane is about 1/2 in the back of the M-A camera.

23.1 Focussing by Measuring (Optional)

The focussing distance can be measured by a tape measure or a laser distance meter or rangefinder (0.947 m in our example) and the focus ring turned to be positioned at that distance (1 m in the example), with some tolerance since the measure is often more precise than necessary.

Although most photographers do not use this measuring method, it is very precise when extremely sharp image quality is required.

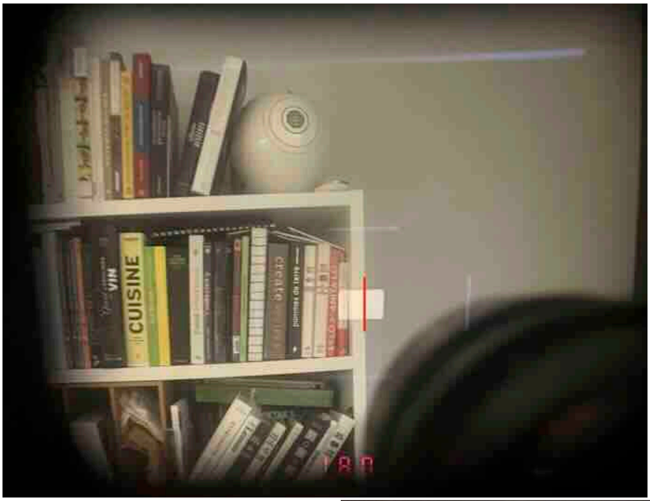
23.2 Focussing with the Viewfinder

The M-A is a rangefinder camera. This means that a coincidence rangefinder (also called telemeter) is incorporated in the M-A and used to determine the distance to a subject. The image taken through the viewfinder must be aligned vertically with the small center rangefinder image taken through the rangefinder window (see figure 4). This alignment is made by turning manually, left or right, the focussing ring (marked in meters (and feet) on the lens). If you want to always turn the focussing ring in the same direction, preset it to ∞, and then turn it right to focus.

The alignment of the viewfinder and rangefinder views by turning the focus ring requires a mechanical linkage between the lens and the viewfinder (described in section 42).

Here is an example with an APO-SUMMICRON-M 1:2/90 ASPH lens at an $f/2$ aperture (which require a precise focussing as explained subsequently).

– When the lens and rangefinder images are vertically aligned (because the focussing ring is on 1.3 m in this example), the lens is focussed and the image on the screen and the photo are clear. The red line on the picture has been added a posteriori to show the perfect alignment.



- When the lens and rangefinder images are not perfectly aligned vertically (because the focussing ring is on ∞ in this example), the image is blurry. The broken red line on the picture has been added a posteriori to make the misalignment clear.

If the subject has no clear vertical line, it is usually possible to move the camera to focus on a vertical line somewhere else at the same distance, then maintain the shutter button half-pressed to keep this distance setting, and come back to the subject to take the photo by fully pressing the shutter down.

Another solution in case of absence of clear vertical line is to turn the camera by 90°, in portrait position, and to focus on an horizontal line.

For very short distances the rangefinder can be imprecise in which case focussing can be done on the screen (or empirically, like 60 cm (centimeter) if you can touch the subject with your arm while holding the camera).

24 Depth of Field

For each of its possible apertures and focus distances, a lens has a corresponding depth of field, that is a zone where the photo is clear, sharp, in focus. Subjects outside that this field will appear blurry on the photo (see figure 7). Of course the transition from sharp to blurry is progressive. The closer in front or farther behind the subject, the more blurry the photo will be. Photographers appreciate a smooth transition. Depending on the lens and aperture, the depth of field can be very large or tiny. Each lens has a

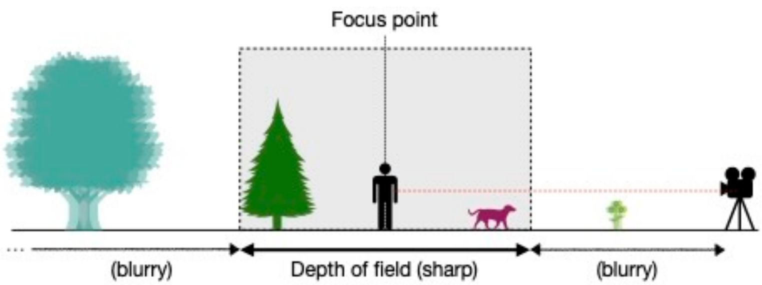


Figure 7: Depth of field

different depth of field which depends on the aperture and is engraved on the unmovable depth of field ring of the lens.

Depth of field ring of the SUMMILUX-M 1:1.4/35 ASPH

Lenses with small focal length have the largest depth of field. Here is the depth of field of the SUPER-ELMAR-M 1:3.8/18 ASPH with focal length of 18mm.



As shown on the middle picture, the aperture is set to $f\,/\,8$ and the focus distance to the subject to 5 m (15 feet for the British Imperial System). The depth of field starts at 1.1 m and is sharp up to infinity ∞ (and beyond :). If the aperture is set to 16, then the depth of field for a focus distance of 5m goes from 0.7 m (on the left picture) to ∞ (and beyond on the right picture). This means that, with this lens, choosing an aperture of 16 and a focus distance of 5 m, all pictures will be in focus.

Lenses with large focal length have the smallest depth of field. Here is the depth of field of the APO-TELYT-M 1:3.4/135 of focal length 135mm with focus distance of 5 m.

For the smallest aperture of 22, the depth of field has a minimum of 4.3 m and a maximum of 6.3 m, which means that the sharp zone, in gray in figure 7, is only two meters deep. At the maximal aperture of 3.4 the depth of field is very small, a few decimeters. Nevertheless this lens is no problem for photographing objects at a long distance such as the summit of a mountain in a landscape or the top of a skyscraper.

Small depths of field have been used in portraiture. For example with an APO-SUMMICRON-M 1:2/90 lens of focal length 90mm at maximum aperture of 2 and a distance to the subject of 1 m

the depth of field is tiny (and not much larger with aperture 16). Therefore, the subject will be sharp but its background blurry, the farther, the blurriest.

In summary,

depth of field:	small	large
aperture:	large (small f-number)	small (large f-number)
focal length:	large	small

A shallow depth of field is in general suitable for a close subject while a greater depth of field may be necessary for a distant subject.

25 Hyperfocal distance (hyperfocus)

The hyperfocal distance (or hyperfocus) is the focussing distance that maximizes the depth of field for a given lens and aperture. When focussing at the hyperfocal distance, the depth of field extends from half that distance to infinity. This is mainly used in landscape photography to ensure that both the foreground and background are sharp, in focus.

On Leica M lenses, the hyperfocus is obtained by turning the focus ring so that the ∞ symbol is positioned in front of the aperture on the depth of field marking.

Hyperfocus at 2.5m on the ELMARIT-M 1:2.8/24 ASPH at aperture $f\,/\,8$ (∞ is set in front of the depth of field marking 8). The depth of field is from 1.2 m to ∞ (both under marking 8).

26 24 × 36 mm Film Cameras

The original photography technique (the Daguerreotype named after its inventor Louis Daguerre in 1839) produced only one picture at a time. The invention of the photographic film by George Eastman at Kodak, first in black and white (monochrome) and then in color allowed for several photos to be taken in succession and exactly reproduced on photographic paper as many times as desired (now on printers).

The film had perforations and the camera used a film advance lever or knob to advance to the next photo. The photographic films could have different sizes and numbers of photos (so called exposures). The 24×36 mm format, designated as 35 mm, was adopted by the Leica M1 in 1959 and this 2×3 ratio of height × width is still used in the Leica M-A. The purely mechanical Leica M-A camera and the Leica M6 incorporating an electronic light meter are the most popular recent Leica film cameras.

27 ISO (Sensitivity)

The films had different sensitivities (improperly called "film speed")[5], the more sensitive films requiring a smaller quantity of light, therefore allowing for faster shutter speeds.

A standardized method of sensitometry was introduced in 1934 and internationalized in the 1974 by the ISO (International Organization for Standardization) to measure film speed.

Popular film ISOs are 100, 200 and 400 but one can also find films at ISO 25, 50, 64, 160, 800, 1600 and 3200. A doubling of film sensitivity is represented by a doubling of the numerical film speed value.

A small ISO produces the best quality photos while the quality may degrade at high ISOs with the appearance of noise, such as unwanted grain, dots, and lines.

[5]The obsession with "speed" dates back to the origin of photography where exposure times were extremely long.

28 Manual Settings of the Camera

To take a photo, the manual settings of the M-A are

1. **ISO:** The sensitivity of the film measured in ISOs. The lower the better to get better photo quality (100 or below offering the best quality, 400 is often chosen as a good quality film sensitivity). This can be remembered at the back of the camera (see the end of section 2) and obviously is always the same for all pictures of a film roll.

2. **Lens:** The choice of the lens, which determines the frame, that is the part of the subject appearing on the photo, and the magnification.

   Moving closer or further from the subject with any lens may be possible, but this will affect the perspective, as discussed in section 12;

3. **Aperture:** The aperture of the lens, the smaller the better (that is, the larger f-number the better) to allow for a deep depth of field (unless bokeh is desired, see section 35);

4. **Shutter speed:** For the shutter speed, the faster is the better to avoid blurring with hand held cameras (but blurred photos by moving the camera or choosing low shutter speed is also popular to get off the beaten track [36, page 76]);

5. **Focussing:** Finally the manual focussing on the subject.

One can use a rule of thumb for the speed and aperture (like the sunny 16 rule in section 4) but using a lightmeter is much more precise.

29 Using a Light/Exposure Meter for Correct Exposure

An exposure meter (or light meter or illuminometer) can measure the amount of light and help decide of the best camera settings before taking a photo. The light meter is coupled to either a digital or analog calculator which, given the film ISO, displays the correct possible choices of shutter speed and f-number for optimum exposure.

The lightmeter can be mounted on the camera (here a KEKS M-mount)

or hand-held.

29.1 Measurement of the Reflected Light

A lightmeter mounted on the camera measures the light reflected by the subject. Setting on the film ISO, the lightmeter has an analog or digital computer to determine the correct aperture (f-number) at any chosen shutter speed. The lens aperture ring must be turned by hand to the advised f-number. If this is not adequate for the desired depth of field, the shutter speed must be modified which will adjust accordingly the lens aperture settings.

For example, we take a photo of books with an M-A on a tripod with a 400 ISO film and an APO-TELYT-M 1:3.4/135 lens at 1.7 m with different exposure measures. Choosing different speeds, the lightmeter mounted on the camera proposes different apertures, but the results are practically the same.

29.2 Exposure Meter Measurement of the Incident Light with a Handheld Exposure Meter

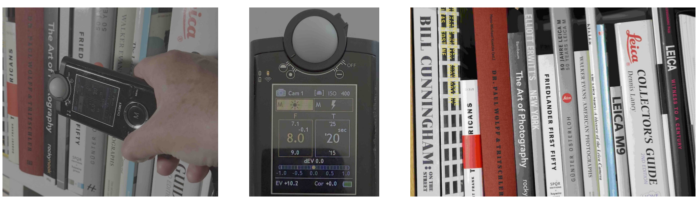
A handheld exposure meter is an alternative method to measure the amount of light.

These exposure meters can be placed just in front of the subject to measure the incident light directly received by the subject from a source (like the sun or an artificial light). Since the amount of light is measured directly from the source, the measurement is usually more precise than the amount of light from the source reflected by the subject (which may absorb some of it).

These exposure meters have a white bulb (called lumisphere) through which the received light quantity is measured. (They can also measure the reflected light, usually when used without the bulb).

29.2.1 Spherical incident light measurement

When the bulb is out/on, the incident light is diffused through the bulb, so that the measure is the mean of the light received around the bulb (that is by the subject on which the instrument is placed).



$f/8$, ISO 400, 1/24 s

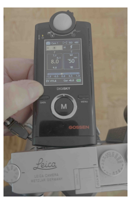
29.2.2 Flat incident light measurement

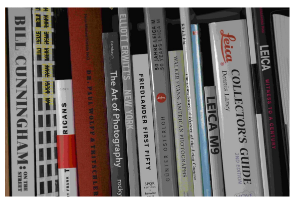
When the bulb is in/off, the measure is restricted to the light amount received exactly at the bulb point.

$f/8$, ISO 400, 1/15 s

29.3 Exposure Meter Measurement of the Reflected Light

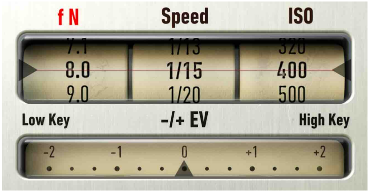
Exposure meters can also be used to measure the light reflected by the subject (so called reflected light measurement). In that case the meter is placed near the camera and pointed to the subject. The zone measured is a disk which size is determined by a fixed or variable angle degree (for example 1 to 40 degrees, 20 degrees in our example) from the meter cell.





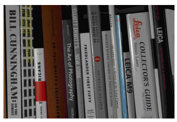
$f/8$, ISO 400, 1/50 s

Phones have light meter applications operating through the phone lenses that are generally less precise than dedicated instruments.

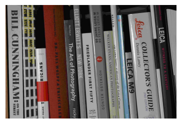


$f/8$, ISO 400, 1/15 s

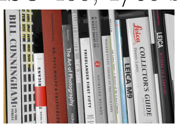
Notice that the previous examples have slow speed but the image is not blurred since the camera is on a tripod. All examples look pretty the same although they are not.



ISO 400, 1/60 s



ISO 400, 1/50 s

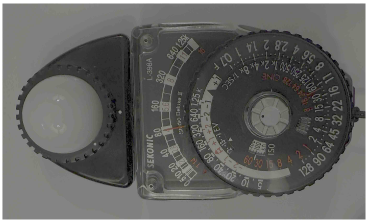


ISO 400, 1/24 s

ISO 400, 1/15 s

Handheld exposure meters can be coupled to a flash to measure the light received when flashing.

An exposure meter may be indispensable for purely mechanical film cameras, with a rangefinder but no electronics at all, such as the Leica M-A (Typ 127). Selenium meters were purely mechanical and existed well before the electronic age, so work without battery. They use a selenium photocell to produce electricity from light and moving a needle on the meter. Most modern versions use amorphous silicon photodetector to measure the intensity of illumination on a surface.



(the measure of 80 foot-candles (about 7.43 lux) at ISO 100 is manually reported under Ĥ so that the proper exposure is 1/250 s at $f/5.6$, 1/30 s at $f/16$, etc.)

30 Stops: Aperture versus Exposure Time versus ISO

Cameras, films, and lenses are all designed so that the aperture and speed settings to receive the appropriate quantity of light needed to make a well-exposed photo are always the same (in a given luminosity situation) whichever lens is chosen. In particular the settings will be the same for all lenses of the Leica M-A. To explain this, the basic notion is that of *stop* (or *exposure value*, EV).

If, for a given amount of light, a photo is too bright/overexposed (respectively dark/underexposed), the photographer must decrease (respectively increase) the exposure, that is the quantity of light received by the camera electronic sensor. There are three possibilities (often, somewhat improperly, called the “exposure triangle”, except that a triangle has three sides).

- **Aperture**: decrease (respectively increase) the aperture (that is increase (respectively decrease) the f-number);

- **Shutter speed**: decrease (respectively increase) the exposure time, that is, increase (respectively decrease) the shutter speed;

- **ISO**: The ISO modification was listed last since it is determined with the choice of the film. **ISO**: decrease (respectively increase) the ISO of the image sensor.

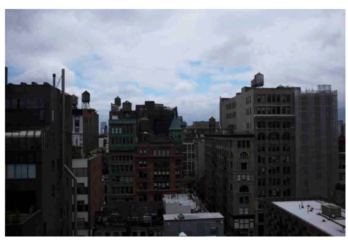
The increment or decrement in these cases are called "f-stops" or simply "stops" by photographers. For example stopping down goes down by one stop (for example from 11 to 8) while stopping up goes up by one stop (for example going up from 4 to 5.6).

Most lenses allow to stop the aperture up or down by a half-stop. Some lenses like the Carl Zeiss Distagon 2.8/15 ZM even offer 1/3 stops (that is 19 possibilities between 2.6 and 22).

Cameras and lenses are designed so that an aperture stop, a shutter speed stop, and an ISO stop allow for the same change of the quantity of light received (up by doubling it, down by dividing it by 2). For math fans, this will be explained in detail in optional section 32.

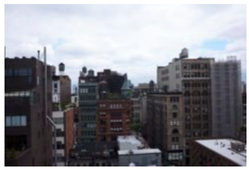
Assume we have used the lens SUMMILUX 1:1.4/35 ASPH to take the following picture

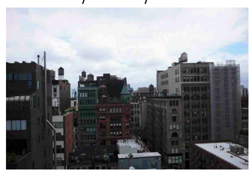
16/250/200



at aperture 16, speed 250, and ISO 200. If we think that is is too dark (a question of taste), we can make the following corrections (on top is the camera screen and below the photo).

11/250/200 16/125/200 16/250/400





The photos look pretty the same since in each case the change was by 1 stop.

So photographers have to look for a compromise since increasing the aperture (decreasing the f-number) may restrict the depth of field, decreasing the speed may yield blurring, and increasing the ISO may introduce noise.

Moreover the results of the camera and lens settings depend slightly on the lens. Figure 8 is an example of two photos taken during the night with the SUMMILUX-M 1:1.4/50 ASPH and the NOCTILUX-M 1:0.95/50 ASPH lenses, both at aperture f / 1.4, speed 1/30 s, and ISO 3200 focussed at ∞. Although the settings are the same, the NOCTILUX-M 1:0.95/50 ASPH photo looks brighter. The lens brightness depends on its design (number and type of elements), coating, and handling of optical aberrations (like chromatic and spherical aberrations) but also on its "speed" (minimal aperture f-number), see sections 32.7 and 32.8.

SUMMILUX-M 1:1.4/50 ASPH

NOCTILUX-M 1:0.95/50 ASPH

Figure 8: Different brightness for same settings

31 EVs (Exposure Values)

An EV (Exposure Value) is a measure of the quantity of light that must be captured by the film in the camera, as defined by given ISO, apertures, and exposure time, according to the light brightness reflected by the subject. The stops as discussed in the previous section 30 correspond to 1 EV.

EVs are further explained in next section 32 (for the math nerds only).

32 A (Long) Digression on the EV Formula for Math Lovers (*Optional*)

If you are resistant to mathematics, just skip this section 32 and go directly to the next section 22, with one click, with a light heart and no regret. A definitely more ambitious solution would be to first refresh your knowledge in mathematics by reading [5].

32.1 The EV Formula

But if you like formulas, here is one

$$EV = \log_2\left(\frac{100 \times f^2}{I \times s}\right) \text{ where } \begin{array}{rl} EV & : \text{Exposure Value} \\ I & : \text{ISO} \\ f & : \text{lens aperture} \\ s & : \text{shutter speed} \\ & \text{in seconds} \end{array} \quad (1)$$

An EV is a number representing the ISO I, aperture f, and exposure time (or shutter speed) s to be set on a camera for the camera sensor (film or electronic) to capture a given quantity of light during s seconds. Lower EV numbers indicate low light (so more light is needed for the photo) while higher EVs indicate more light (so less light is needed for the photo). This means that an EV is also

In a dark, unlit room Pointing at lit light bulb

Figure 9: EV measurement

a measurement of the subject brightness based on camera settings (different from but related to luminance based on photometry in optics). In a dark, unlit room, the exposure time with ISO 100, during 1 s, with aperture of $f/1.0$ of the camera is $EV = \log_2 1 = 0$ (see figure 9). If the quantity of light captured by the camera sensor and the subject brightness coincide, the photo is well-exposed.

All camera combinations of the ISO, f-number, and shutter speed that yield the same exposure have the same EV. An incrementation of the EV by 1 corresponds to 1 stop (either on the ISO, aperture, or shutter speed), as explained in section 30 and proved in section 32.14.

As shown in figure 9, a subject brightness EV can be measured by an external light meter (see section 29 for more details).

For example an exposure $EV = 14$ can be achieved by ISO $= 100$, $f = 22$, and $t = \frac{1}{30}$ since $\log_2(22^2 \times 30) = 13.8257538329 \simeq 14$ (among other solutions).

Given a measured EV, formula (1) provides the possible ISO I, aperture f, and shutter speed s, that can be chosen to have the correct exposure for that measured EV.

32.2 Using the EV Formula to Determine the Focal Length

Notice that the camera-mounted light meter has two buttons to increase + or decrease - the ISO so as to select the ISO of the film mounted in the camera. Moreover, the light meter has a speed wheel, mechanically linked to that of the camera so as to choose the exposure time.

Knowing the ISO I and exposure time s, the lightmeter calculator computes the aperture f using formula (1). The photographer must then turn the lens aperture ring to that focal length f. If its depth of field is inadequate, one can change the selected speed to get other possible focal lengths.

If the indicated focal length does not exists on the lens, a close one must be chosen (for example 11 for 10F).

32.3 Apertures of a Lens

To understand formula (1), let us first understand the magic aperture numbers 1.4, 2. 2.8, 4, 5.6, 8, 11, 16, 22 appearing on the aperture ring of lenses, already discussed in section 21.

The powers of the square root of 2 are [5, page 122]

- $\sqrt{2}^1 = \sqrt{2} = 2^{\frac{1}{2}} = 1.41421356 \simeq 1.4$ and $1.41421356 \times 1.41421356 = 1.99999999 \simeq 2$ (by $\sqrt{a} \times \sqrt{a} = a^{\frac{1}{2}} \times a^{\frac{1}{2}} = a^{\frac{1}{2}+\frac{1}{2}} = a^1 = a$ since $\sqrt{a} = a^{\frac{1}{2}}$ and $a^m \times a^n = a^{m+n}$);
- $\sqrt{2}^2 = (2^{\frac{1}{2}})^2 = 2^{\frac{1}{2}\times 2} = 2^1 = 2$ (by $((a^m)^n) = a^{mn}$);
- $\sqrt{2}^3 = 2.82842712 \simeq 2.8$;
- $\sqrt{2}^4 = \sqrt{2}^2 \times \sqrt{2}^2 = 2 \times 2 = 4$;
- $\sqrt{2}^5 = 5.65685425 \simeq 5.6$;
- $\sqrt{2}^6 = 8$;
- $\sqrt{2}^7 = 11.3137085 \simeq 11$;
- $\sqrt{2}^8 = 16$;
- $\sqrt{2}^9 = 22.627417 \simeq 22$.

So the apertures engraved on the lens are the rounded powers of $\sqrt{2}$.

32.4 Effect of the Aperture Diameter on the Quantity of Light Captured by the Sensor Per Second

Lenses have an aperture ring marked by different f-numbers, such as 1.4, 2. 2.8, 4, 5.6, 8, 11 or 16 for the SUMMILUX-M 1:1.4/50 ASPH. The lens has a mechanism, called a diaphragm, that will change the diameter d of the aperture (also called entrance pupil) when turning the aperture ring to different

f-numbers (see figure 6). This changes the size of the entrance pupil hence the quantity of light reaching the image sensor during a shot (say of 1 second).

The entrance pupil is a disk (or very close to be a disk). Therefore, the surface of the entrance pupil is πr^2 where r is the radius of the entrance pupil set by the diaphragm when turning the aperture ring, that is $\pi(\frac{d}{2})^2 = \pi\frac{d^2}{4}$ for the diameter $d = 2r$.

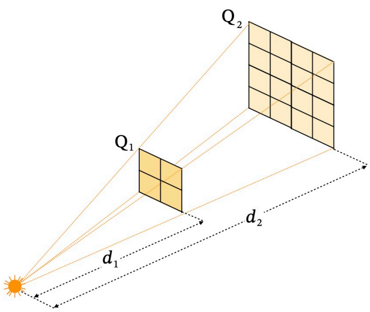
Increasing aperture by one stop, will decrease the diameter by a factor $\sqrt{2}$ so the surface of the aperture disk is now $\pi(\frac{d}{2\times\sqrt{2}})^2 = \pi\frac{d^2}{(2\times\sqrt{2})^2} = \pi\frac{d^2}{2^2\times\sqrt{2}^2} = \pi\frac{d^2}{4\times\sqrt{2}^2} = \pi\frac{d^2}{8} = \frac{1}{2}\pi\frac{d^2}{4}$. Therefore increasing the aperture by one stop divides the surface $\pi\frac{d^2}{4}$ of the aperture by 2, hence divides by 2 the quantity of light received per second.

Decreasing aperture by one stop, will increase the diameter by a factor $\sqrt{2}$ so the surface of the aperture disk is now $\pi(\frac{d\times\sqrt{2}}{2})^2 = \pi\frac{(d\times\sqrt{2})^2}{2^2} = \pi\frac{(d^2\times\sqrt{2}^2)}{4} = \pi\frac{(d^2\times 2)}{4} = 2\times\pi\frac{(d^2)}{4}$ Therefore decreasing the aperture by one stop multiplies the surface of the aperture by 2, that is, doubles the quantity of light received per second.

We remember from this section that the quantity of light received by the image sensor from a lens with entrance pupil diameter d is proportional to $\pi\frac{d^2}{4}$ that is of the form $c_a d^2$ where c_a is a constant coefficient that depends only on the lens/objective (for example the quality of the glass and coating of the lenses in the objective). Because a stop changes d by a factor $\sqrt{2}$, $c_a d^2$ is changed by a factor 2.

32.5 Effect of the Focal Length on the Quantity of Light Captured by the Sensor Per Second

The inverse square law of distance in optics is a law of physics, that is a mathematical formulation of an immutable observation of a natural phenomenon. This inverse square law of distance states that the intensity of light from a point source is inversely proportional to the square of the distance from the source. For example doubling the distance reduces the quantity of light received to one quarter. This is clearly visible when using a flash, since close subjects are much brighter than distant ones on the photos.



$$Q_1 \times (d_2)^2 = Q_2 \times (d_1)^2$$

Figure 10: Inverse square law of distance in optics

If a subject reflects the same quantity of light through lenses of different focal lengths fl_1 and fl_2 with the same aperture (that is same entrance pupil diameter d), this quantity of light will be more dispersed on a larger part of the sensor with large focal lengths and more concentrated on a smaller part of the sensor with small focal lengths, as illustrated on figure 10. Considering that the light source is the entrance pupil, we have

$$\frac{Q_1}{(fl_2)^2} = \frac{Q_2}{(fl_1)^2}$$

We remember from this section that the quantity of light received per second by the image sensor from a lens with a focal distance fl is inversely proportional to fl^2, that is of the form $c_{fl}\frac{1}{fl^2}$ where c_{fl} is a constant coefficient that depends only on the lens/objective (for example the optical clarity of the lenses in the objective).

32.6 Combined Effect of the Aperture Diameter and the Focal Length on the Quantity of Light Captured by the Sensor Per Second

We can now combine the effect of the aperture diameter d of the lens and the chosen focal lens fl on the quantity of light reaching the image sensor per second. It increases as $c_a d^2$ with the diameter d but is attenuated by a factor $c_{fl}\frac{1}{fl^2}$ because of spreading the gathered light over an area on the sensor inversely proportional to the square of the focal distance fl. The quantity of light receives per second by the sensor is of the form $c_a d^2 \times c_{fl}\frac{1}{fl^2}$ that is $c\frac{d^2}{fl^2}$ where $c = c_a \times c_{fl}$ is a constant specific to the lens.

32.7 Entrance Pupil Diameter

Lenses (of focal length fl) are always designed to have a diaphragm, such that, for each f-number f chosen on their aperture ring, the entrance pupil is opened to a diameter d

satisfying

$$f = \frac{fl}{d} \qquad \text{or} \qquad d = \frac{fl}{f} \tag{2}$$

This design ensures that any two lenses with different focal lengths fl_1 and fl_2 but same aperture f receive the same quantity of light per second (or very close ones).

To prove it, consider two lenses of respective focal lengths fl_1 and fl_1 set on the same aperture with f-number f. Then the quantity of light each lens receives per second is, by section 32.6,

$$\begin{array}{lll} & c_i\frac{(d_i)^2}{(fl_i)^2} & \text{for lens } i = 1, 2 \\ = & c_i\frac{(\frac{fl_i}{f})^2}{(fl_i)^2} & \text{by (2)} \\ = & c_i\frac{(\frac{(fl_i)^2}{f^2})}{(fl_i)^2} & \text{by } (\frac{a}{b})^n = \frac{a^n}{b^n} \\ = & c_i\frac{(fl_i)^2}{f^2 \times (fl_i)^2} & \text{by } \frac{\frac{a}{b}}{c} = \frac{a}{b} \times \frac{1}{c} = \frac{a}{b \times c} \\ = & \frac{c_i}{f^2} & \text{by simplification } \frac{a}{a} = 1 \text{ and } a \times 1 = a. \end{array}$$

This calculation proves that the two lenses receive the same quantity of light per second since in practice $c_1 \simeq c_2$ although they might be slightly different, as shown in figure 8 at the end of section 30, because of slightly different lens designs or use of different UV filters capturing more or less visible light.

32.8 Speed (Maximal Aperture) of a Lens

The "speed" of a lens is its minimal f-number F, corresponding to its maximal aperture. The "speed" is an inappropriate term, but follows from the fact that fast lenses (such as $F = 0.95$ or $F = 1.4$) allows for rapid shutter speeds, that is small exposure times, resulting in less blurring.

The "speed" of a Leica lens is written on that lens, for example, the SUMMILUX-M 1:1.4/50 ASPH is a lens of focal length 50 mm and maximal f-number $F = 1.4$. In general it will be written $1 : F/fl$ where F is the maximal aperture of the length ($F = 1.4$ in fact $\sqrt{2} = 1.41421356$ in our example) and fl is the focal length ($fl = 50$ mm in our example).

Applying equation (2) to this maximal aperture case, we get the maximal aperture F available which corresponds on that lens to a diameter d_m, such that

$$F = \frac{fl}{d_m} \qquad \text{or} \qquad d_m = \frac{fl}{F} \tag{3}$$

So for the SUMMILUX-M 1:1.4/50 ASPH the diameter d_m will be $\frac{50}{1.4}$ $= 35.7714$ while for the NOCTILUX-M 1:0.95/50 ASPH is will be $\frac{50}{0.95}$ $= 52.631$, as shown on the following pictures

1:1.4/50

1:0.95/50

The $1 : F/fl$ designation on Leica M lenses derives from $d_m = \frac{fl}{F}$ in equation (3). The "1:" prefix in Leica M lens designations signifies a division that is $\frac{1}{F}$ while / is multiplication by fl since $1 : F/fl = (\frac{1}{F})/fl = \frac{\frac{1}{F}}{fl} = \frac{fl}{F}$. For example

"1:2/75" on the APO-SUMMICRON-M 1:2/75 ASPH lens represents a maximum aperture diameter $d_m = \frac{\frac{1}{2}}{75} = \frac{75}{2} = 37.5$ mm[6]. Equivalently, a lens of focal lens 75 mm and maximal aperture 37.5 mm has a "speed", maximal aperture, or minimal f-number 2.

32.9 Effect of the ISO on the Quantity of Light Captured by the Sensor Per Second

The ISO film speed (more precisely film sensitivity nowadays electronic image sensor sensitivity) has been defined so that when doubling the ISO, the film sensitivity doubles, so that the quantity of light fixed on the film or image sensor per second doubles. Taking the base ISO 100, the ISO 200 doubles the quantity of light captured per second, ISO 400 quadruples it, and so on for ISO 800, 1600, 3200. So the contribution of the ISO sensitivity I to the quantity of light captures by the sensor per second is $\frac{I}{100}$. Moreover doubling the ISO doubles the quantity of light captures per second, that is, corresponds to one stop.

32.10 Effect of the Exposure Time (Shutter Speed) on the Quantity of Light Captured by the Sensor Per Second

The shutter speeds on the dial of figure 1 (more detailled in section 19), are $\frac{1}{1000}$, $\frac{1}{500}$, $\frac{1}{125}$, $\frac{1}{60}$, $\frac{1}{50}$ (for a flash), $\frac{1}{30}$, , $\frac{1}{15}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 4, 8, being each time multiplied by 2 (or so for

[6]The solidus symbol / was introduced by the English logician Augustus de Morgan in 1845 while the colon : was introduced by the German mathematician Gottfried Leibnitz in 1659.

$\frac{1}{125} \to \frac{1}{60}$ and $\frac{1}{15} \to \frac{1}{8}$ as well as $\frac{1}{n}$ written n to ease engraving of shutter speed on the dial.

The quantity of light captured by the image sensor is proportional to the exposure time (shutter speed) s. This is the quantity received during one second multiplied by s so is of the form $c_s s$ where c_s is the quantity of light captured during one second. It follows that changing the shutter speed by one stop down double the quantity of light captures per second, that is, corresponds to one stop.

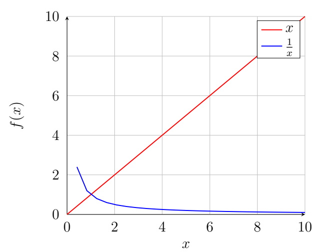
32.11 Combined Effect of the Aperture, Focal Length, and ISO on the Quantity of Light Captured by the Sensor Per Fraction of Second

We have seen that the contribution of the lens focal length *fl* and aperture (f-number) f is $\frac{c}{f^2}$ (thanks to the clever choice (2) of the diameter d of the entrance pupil). That of the ISO I is $\frac{I}{100}$. That of the shutter speed s is $c_s s$. Combining these effects is multiplicative, since one stop down on the ISO and one stop down on the aperture and one stop down on the speed divide the quantity of light received by the sensor by $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$. It follows that the cumulated effect of the aperture, focal length, and ISO on the quantity of light captured by the sensor during s seconds is $\frac{c \times I \times c_s s}{f^2 \times 100}$ of the form $q\frac{I \times s}{100 \times f^2}$ where q is the quantity of light captured by the image sensor at ISO 100, for an f-number 1, during 1 second. The coefficient q can be measured precisely by photometry. The formula $q\frac{I \times s}{100 \times f^2}$ is close to (1) but different because we have reasoned on the quantity of light received by the film or image sensor per second whereas (1) is about the exposure value.

32.12 What is the EV (Exposure Value)

The quantity of light $q\frac{I\times s}{100\times f^2}$ captured in s seconds increases when increasing the ISO I, the exposure time s, or the aperture (which decreases the f-number) so that the photo will be brighter, if not overexposed. So higher values of $q\frac{I\times s}{100\times f^2}$ indicate more light captured.

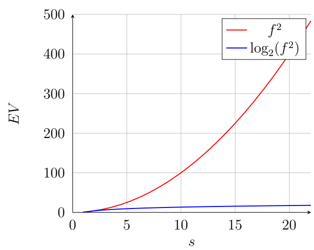
On the contrary, EVs are not about the quantity of light received but about the camera settings to cope with a given quantity of light received. So if the quantity of light received is very high, we must decrease the ISO, shutter speed, and aperture (that is increase the f-number) to capture less of the received light so that higher EVs indicate less light to capture. If the quantity of light received is very low, we must increase the ISO/aperture/speed (that is decrease the f-number) to capture more of the received light so that lower EV numbers indicate more light to capture. This corresponds to the inverse $\frac{1}{q\frac{I\times s}{100\times f^2}} = \frac{100\times f^2}{q\times I\times s}$, as shown when comparing x (in red) and $\frac{1}{x}$ (in blue),



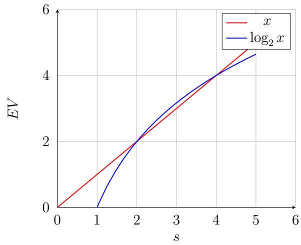
Decreasing the ISO I or the shutter speed s or decreasing the aperture by increasing the f-number will increase the quantity $\frac{100\times f^2}{q\times I\times s}$, that is increase the quantity of light reaching the image sensor. If more light reaches the image sensor, it must capture less of the light for a correct exposure. Therefore, like the EV, higher values of $\frac{100\times f^2}{q\times I\times s}$ indicate less light to be captured while lower values of $\frac{100\times f^2}{q\times I\times s}$ indicate more light.

32.13 Why the logarithm?

Without the logarithm $\log_2$ [5, page 443] in formula (1), the value $\frac{100\times f^2}{q\times I\times s}$ grows rapidly. For example, with $q = 1$, ISO $I = 100$, and shutter speed $= 1$ s, the EV, which is f^2 in this case, is plotted in red as a function of f and rapidly reaches large numbers. By applying the $\log_2$ the numbers remains small (say less than 25, bright sun on snow being about 17). This is clearly shown by $\log_2 f^2$ plotted in blue. Moreover multiplications become additions (since $\log_2 a\times b = \log_2 a + \log_2 b$) which simplifies calculations based on $\sqrt{2}$ (since $\log_2(\sqrt{2}) = \frac{1}{2}$ and $\log_2(2) = 1$).



Because units can be chosen arbitrarily (such as the Kelvin (K), Celsius (°C), and Fahrenheit (°F) scales for temperature), we can arbitrarily scale by $\log_2$ in (1) that is $\log_2(q\frac{I\times s}{100\times f^2}) = \log_2(\frac{I\times s}{100\times f^2}) + \log_2 q$ and ignore the translation term $\log_2 q$. Moreover the logarithm is an increasing function. The larger is x, the larger is $\log_2 x$, as shown thereafter.



It follows that the requirement that higher EVs indicate less light to be captured while lower EVs indicate more light, as satisfied by $\frac{100 \times f^2}{I \times s}$, is preserved by taking the logarithm $\log_2$.

This idea of logarithmic scale is frequent in physics to measure quantities with a broad range of values such as exponential growth. Another example is decibels to measure sound intensity levels relative to a reference value.

Finally, we have (hopefully) explained the meaning of the EV formula (1).

32.14 EVs and Stops

Observe that to stop up by one stop, we can either

- Increase the aperture by 1 stop, which multiplies f by $\sqrt{2}$ so that $(f \times \sqrt{2})^2 = 2 \times f^2$ so that the logarithm $\log_2$ increases the EV by 1 (since $\log_2(2x) = \log_2 x + \log_2 2 = \log_2 x + 1$), or

- Increase the ISO by 1 stop, that is double it, so that, again, the logarithm $\log_2$ increases the EV by 1, or finally

- Decrease the shutter speed by 1 stop, which multiplies s by 2, so that, once again, the logarithm $\log_2$ increases the EV by 1.

We conclude that stopping up by one stop increases the EV by 1, and similarly stopping down by one stop decreases the EV by 1.

More details on the exposure value can be found on Wikipedia, in particular its relation with the physical notion of luminance to characterize the brightness of subjects.

It just remains to cite the German camera shutter manufacturer Friedrich Deckel who is credited with developing the Exposure Value (EV) system in the 1950s.

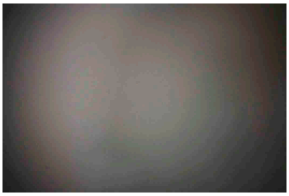
33 Lens Flare

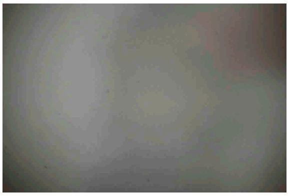
Lens flare and glare is often caused by very bright sources, giving the impression that the photo has been invaded by too much light. The problem is generally solved by slightly reorienting the camera.

Modern lenses are coated to avoid this phenomenon as much as possible by altering the way in which the lens reflects and transmits light. A lens hood can also reduce lens flare.

34 Vignetting

The subject seen in a disk by a lens must be projected to the 2:3 rectangle sensor, which may have undesirable optical effects. One of them is vignetting that is a reduction of an image's brightness on its periphery, often in the corners. Here is a first photo of a white wall taken with the Carl Zeiss DISTAGON 2.8/16 ZM lens, where vignetting is visible. By screwing a filter which is darker in the center in front of the lens (Carl Zeiss Center Filter (-1,5 EV) for the Distagon 2,8/15 ZN), the vignetting is attenuated, on the second photo, at the expense of exposure, which is reduced by the filter.



35 Bokeh

Bokeh is the effect described in section 24, where the depth of field is very small so that the subject is sharp with proper focussing whereas the foreground and background are blurry. Leica M 50mm, 75mm, and 90mm lenses are generally appreciated in portraiture for their smooth bokeh. The bokeh can be accentuated by a center spot filter to further blur the image periphery.

In this example, taken with a handheld M-A equipped with the 2025 re-issue of the SUMMILUX-M 1:1.4/50 CLASSIC $f\,/\,1.4$

lens at 0.7 m and 1/200 with close focussing with the screen on the yellow spadix of a spathe of *Anthurium*, the foreground and background are blurry. This lens is known for its smooth creamy bokeh.

The bokeh can be accentuated using a warm center spot filter.

36 UV Filters

A UV filter (or UV (ultraviolet) pass filter) is often screwed in front of the lens to protect the glass and its coating. This may harm contrast and sharpness and be at the origin of lens flare (see section 33). An alternative is to use a hood adapted to the lens.

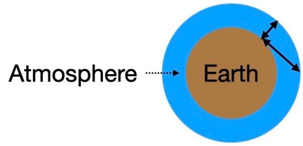
37 ND Filters

ND (neutral-density) filters can be used to reduce the quantity of light entering the lens (without changes in color rendition), for example to extend the exposure time. Variable neutral-density filters have several positions allowing to modify the quantity of light blocked.

An exposure correction using the ISO, shutter speed, and aperture is usually preferable, except for exceptional situations (such as long exposures of very bright subjects that would yield overexposed photos or to get bokeh in a portrait with a large aperture and bright lightning which cannot be compensated by a low ISO and fast speed).

38 Rayleigh Scattering

Everywhere on earth, the atmosphere is thiner when looking overhead and thicker when looking towards the horizon.



It follows that the blue sun light is less filtered by the atmosphere when looking straight up than it is when looking towards the horizon. This is called Rayleigh scattering. The result is that the sky is a much darker blue at the top of a photo than it is at the horizon, where it can even be white. The eye and the brain compensate but the camera doesn't. Moreover the dynamic range of the eye is much better than that of a camera, which means that a camera cannot capture details both in bright and darker regions of the subject. There are three possible remedies.

- use a neutral-density filter, see section 39;
- use a polarizing filter, see section 40 and Rayleigh sky model;
- choose photographic film and paper with extended dynamic range or combining photos taken at different exposures.

39 ND Graduated Filters

A graduated neutral-density (ND) filter can be used to reduce the quantity of light entering part of the lens, typically half of it, with a gradual transition from one half to the other.

It can be used to darken a bright sky so that both the sky and subject can be properly exposed.


without ND Grad filter


with ND Grad filter

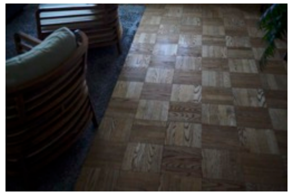
40 Circular Polarizer

A circular polarizer can be mounted in front of the lens to reduce light polarization (for the 16-18-21mm lens below).

A filter adapter may be necessary to adjust to the lens size.

By slowly turning the mobile part of the circular polarizer right or left, polarization will be attenuated (but not if the sun is in front or just behind) or even completely suppressed (if the sun is at 90 degrees).

Polarized light



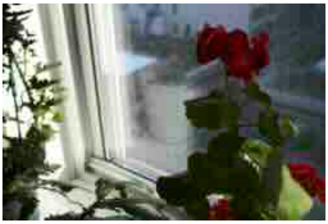
Reduction of polarization with a circular filter

41 Macro Photography

The M-A offers two possibilities for Macro photography:

- The magnifying glass Leica ELPRO E52 can be screwed in front of some lenses (in the following example a Voigtländer NORTON 40mm F 1.2)

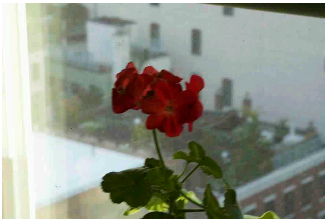
Focussing must be with the screen (with the FN (function) button to magnify the screen)[7] The magnifying effect of the Leica ELPRO E52 is seen by comparing the following two pictures

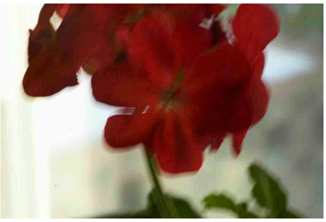


– The Leica Macro-Adapter-M, here mounted on a Leica MACRO-ELMAR-M 1:4/90 lens (which must be extended by turning and pulling the front of the lens before using) extends the focal length of M-lenses, which has a magnifying effect, as explained in section 12.

[7] If the camera settings have been changed, maintain the FN (function) button pressed down until a menu appears and select Focus Aid.

Again focussing must be through the screen (since the viewfinder is unchanged while the focal length of the lens is increased by the adapter).





Notice that computer applications such as Darktable, GIMP, GraphicConverter, Lightroom, Luminar Neo, or Preview on MacOS and their counterparts on Linux and Windows can be used to select part of a image, but this reduces the image resolution, which is not the case with macro photography.

42 Additional Information on How the Rangefinder Works (*Optional*)

The Leica M camera is a rangefinder camera which has a coincidence rangefinder (also called coincidence telemeter) using the principle of triangulation. The principle has been known since antiquity. It was applied by the military to measure the distance to distant targets. Leica's credit was to miniaturize the coincidence rangefinder so that it would fit in a compact camera.

We have explained in section 23.2 how to focus using the viewfinder by moving the focus ring to have the viewfinder and rangefinder images coincide. The rangefinder is purely mechanical and optical so does work when the M-A is turned off or on the Leica M-A (Typ 127), without needing a battery. For those enjoying technique, we now explain how that works. If you hate physics, skip to the conclusion since you already know from section 23.2 how to focus with the rangefinder.

42.1 Principle of the Coincidence Rangefinder

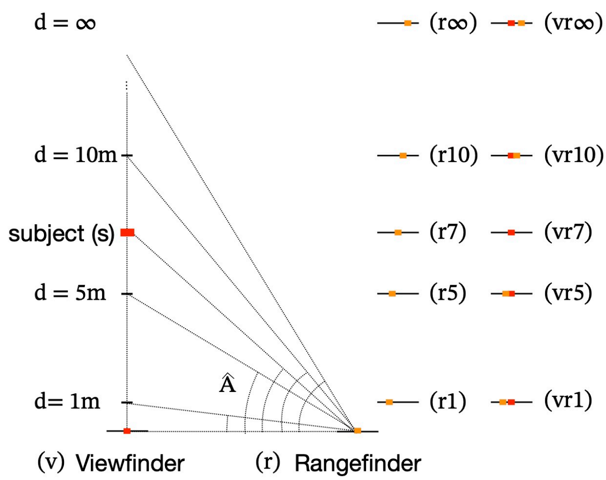


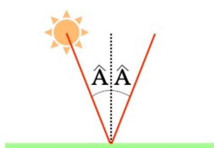
Figure 11: Principle of the rangefinder

The rangefinder idea is shown on figure 11. The subject (s) is viewed at a fixed horizontal position in the viewfinder (v) while it can be viewed at different angles $\hat{A}$ in the rangefinder (r). Each angle $\hat{A}$ corresponds to different horizontal positions in the rangefinder. These related angle and horizontal positions depend on the distance from the camera electronic sensor to the subject. For each angle $\hat{A}$, hence distance d, the subject will appear shifted left or right horizontally (that is (r1) at 1m, (r5) at 5m, (r10) at 10m, and (r∞) at infinity, as seen on figure 11. The two images exactly coincide only at the focus distance, (vr7) on figure 11. They differ at all other distances (vr1), (vr5), (vr10) and (vr∞).

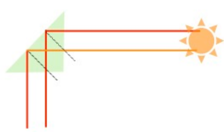
42.2 Reflective Prismes

We must now understand how it is possible to have the image of the subject (s) shift left or right depending on the distance d that is the angle Â.

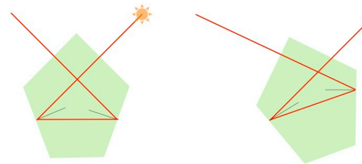
This is an optical device built out of prisms. Reflective prisms are transparent (glass) objects that use flat surfaces to redirect the light in another direction, like a mirror. The angle Â which the incident light beam makes with the perpendicular to the mirror is equal to the angle Â which the reflected light beam makes to this same perpendicular to the mirror.



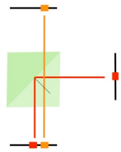
Right-angle prisms are common for redirecting a light beam by 90 degrees. Viewed from above, this is



Pentagonal prisms can redirect a light beam at different angles when rotating them.

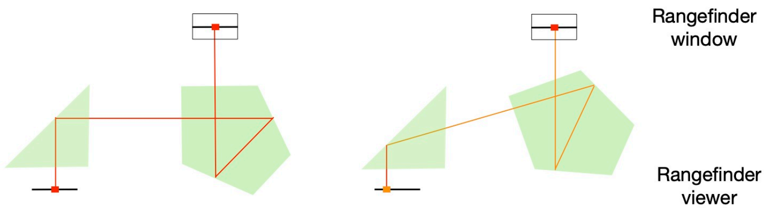


Finally a cube beam splitter is made of two prisms that form a cube. One beam of light is transmitted while the other at 90 degrees is reflected so that both beams are directed into a common path.



42.3 Realization of the Rangefinder

We can now use prisms so that at difference distances d, hence angles $\hat{A}$, the subject (s) will be seen at different horizontal positions in the rangefinder views (r1) to (r∞) in figure 11.



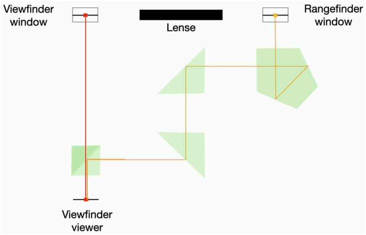
The pentagonal prism is mobile. By rotating it, we have different angles $\hat{A}$ on figure 11 each one having the image appears at a different position in the rangefinder viewer.

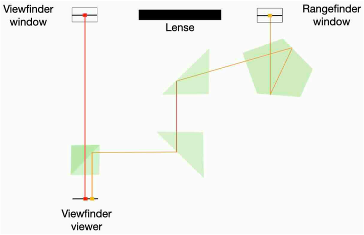
42.4 Superposition of the Viewfinder and Rangefinder Views

On early screw mount Leica cameras, the viewfinder and rangefinder small viewers were separate.

The photographer used the rangefinder viewer to focus and then the viewfinder viewer to compose. This is still the case when using an external viewfinder for short focal lengths such as 10mm, 15mm, 21mm, and 24mm, see section 15. The viewfinder and rangefinder were first merged into a single window on the M-mount Leica M3 introduced in 1954.

A cube beam splitter (plus a right-angle prism) is used to superpose the viewfinder and rangefinder images so as not to have two different viewers but a single one.





In Leica M cameras, the rangefinder window is smaller that the viewfinder window and so appears in a small rectangle centered in the middle of the viewfinder view.

42.5 Connection of the Rangefinder and the Lens

It remains to understand how the lens acts on the pentagonal prism and turn it to have the two images coincide when the lens is in focus.

The lenses have a focus ring graduated in meters (m) (and feets usually marked in red or orange). Turning this ring will move the lens elements in and out, each position of these elements corresponding to a graduation bringing the subject (s) in sharp focus at that designated distance, see section 23. These lens element positions and corresponding distances of sharp focus have been calculated once for all by the lens designer and engraved on the lens (together with the corresponding depth of field, see section 24).

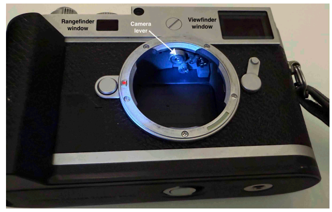
Assume that through the viewfinder (v), the photographer points to the subject (s) so as to see it (smaller) in the viewfinder. The focus ring is mechanically linked to the rangefinder pentagonal prism, so that at different distances on the focus ring, the pentagonal prism will be turned by different angles $\widehat{\mathrm{A}}$. As explained previously, the subject seen in the rangefinder window will be reflected at different angles $\widehat{\mathrm{A}}$ by the pentagonal prism and so will appear shifted left or right horizontally (that is (r1) when the lens is focussed at 1m, (r5) at 5m, (r10) at 10m, and (r∞) when the lens is focussed at infinity, as seen on figure 11).

To mechanically link the lens focus ring to the camera, the lens has a notch and a control cam which is a mechanical piece behind the notch moving up and down. The position of the control cam depends on the focus distance (see figure 12 at 0.7m and infinity ∞ with a SUMMILUX-M 1:1.4/35 ASPH lens). At the top of the screw mount of the camera is a roll acting as a lever which is moved by the moving control cam of the lens behind the notch (see figure 12 above).

When moved by the lens, this lever will rotate the pentagonal prism changing the rangefinder angle of view $\widehat{\mathrm{A}}$ hor-

control cam position at 0.7m

control cam position at ∞



camera lever

Figure 12: Mechanical link between the lens focus and camera

izontally, to produce the images (r1) to (r∞) on figure 11.

Of course to have the rangefinder work properly, there are a lot of calculations using the laws of optics and mechanics to position properly the two images visible in the viewfinder with the focus ring movements on the lens. At the time of the first Leica M cameras this was done by hand. This is now done with computers using more sophisticated mechanical and optical modeling which explains, together with better materials, the progresses in lenses.

The mechanical coupling of the focussing ring to the pentagonal prism of the rangefinder in the camera is the same for all M-lenses of any focal lens. So it is part of the lens design to move the camera lever (on the right image of figure 12) the same way for all lenses at the same focussing distance. You can compare for example figure 12 for the SUMMILUX-M 1:1.4/35 ASPH lens with figure 13 for the much smaller SUMMARON-M 1:5.6/28 lens. The position of the con-

control cam position at 1m | control cam position at ∞

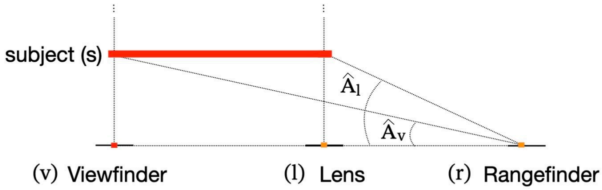
Figure 13: Notch and a control cam on a lens

trol cam visible through the notch is the same at the same focus distance despite the fact that the two objectives have different sizes hence need different extensions of the lens for focussing.

This also means that you can use your camera to measure the distance to a (not too close) subject by focussing on it, with any lens.

42.6 Parallax Error

As already observed in section 23.2, focussing with the rangefinder at short distances (0.7 to 1 m) can be imprecise. This is due to the fact that the viewfinder is not above the lens but on its side (see figure 4). It follows that the angle measured by the rangefinder with respect to the viewfinder differs from that with respect to the lens. This introduces a parallax error, which is important enough only for short distances.



The angles $\hat{\mathrm{A}}_{\mathrm{v}}$ and $\hat{\mathrm{A}}_{\mathrm{l}}$ differ significantly at close distances so that the rangefinder measure which should be by $\hat{\mathrm{A}}_{\mathrm{l}}$ is by the smaller angle $\hat{\mathrm{A}}_{\mathrm{v}}$, hence, as shown on figure 11, too short.

In that case, one can use focus by empirical measurement (such as about 60 cm if you can touch the subject with your arm while holding the camera).

43 Conclusion

We have explained the basic concepts in photography and elementary use of the Leica M-A. We have added optional technical explanations to appreciate the ingenuity of photographers over almost two centuries!

The Leica M-A instruction manual [23] is indispensable to go beyond an elementary use of the Leica M-A and explore its numerous other possibilities.

Research on photography goes on, in particular in computer science, where is it called computational photography. The research results are published in scientific conferences such as the annual IEEE *International Conference on Computational Photography*,

Numerous books are available to explain the historical [21, 30, 31, 44], technical [2, 9, 24, 36], and artistic aspects [1, 3, 4, 6, 7, 8, 10, 11, 12, 13, 14, 15, 17, 18, 20, 22, 25, 26, 27, 28, 29, 32, 33, 34, 35, 38, 39, 41, 42, 43] of photography, including for Leica cameras [19, 21, 30, 31, 36, 37].

Magazines, like LFI, Modern Photography and Popular Photography (PopPhoto), review contemporary photography.

Online discussion groups such as Irys can be used to share interest in photography.

Going to *photography museums* (such as the International Center of Photography (ICP), The Met, or the MOMA in New York, the Photography centre in London, the Albert Kahn museum in Boulogne-Billancourt near Paris, the Maison européenne de la photographie, the Fondation Henri Cartier-Bresson, the Centre Pompidou in Paris, or the Maison de la photographie Robert Doisneau in Gentilly near Paris), visiting *temporary expositions* (in particular in Leica stores) and *photography galleries* (like Danziger, Howard Greenberg, and Sorrel Sky in New York, Autograph and The Photographers' Gallery in London, Polka and Le Bal, or the avant-garde François Bourdoncle, in Paris), attending *photography festivals* (such as Photoville in Brooklyn, Paris Photo New York in New York, NY, USA, FORMAT in Derby, Photo Oxford in Oxford, Photo London in London, UK, and the Rencontres d'Arles, the Visa pour l'image in Perpignan, and the Paris Photo, France), as well as joining *photography collectives* (such as NYC Street Photography Collective or the London Alternative Photography Collective) can also be an inexhaustible source of endless inspiration.

Happy photo shooting! (More precisely, focussing, framing, and shooting. :)

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Introduction to Photography with the Leica M-A

Patrick Cousot

A short, simple, and illustrated introduction to the fundamental concepts of analog photography (with a few optional technical explanations), and their practical application with a Leica M-A.

Patrick Cousot is professor of computer science and amateur photographer.

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