Illustrations courtesy
Life Magazine Encyclopedia of Photography

Lens Openings & Shutter Speeds

Controlling Exposure & the Rendering of Space and Time

Equal Lens Openings/ Double Exposure Time

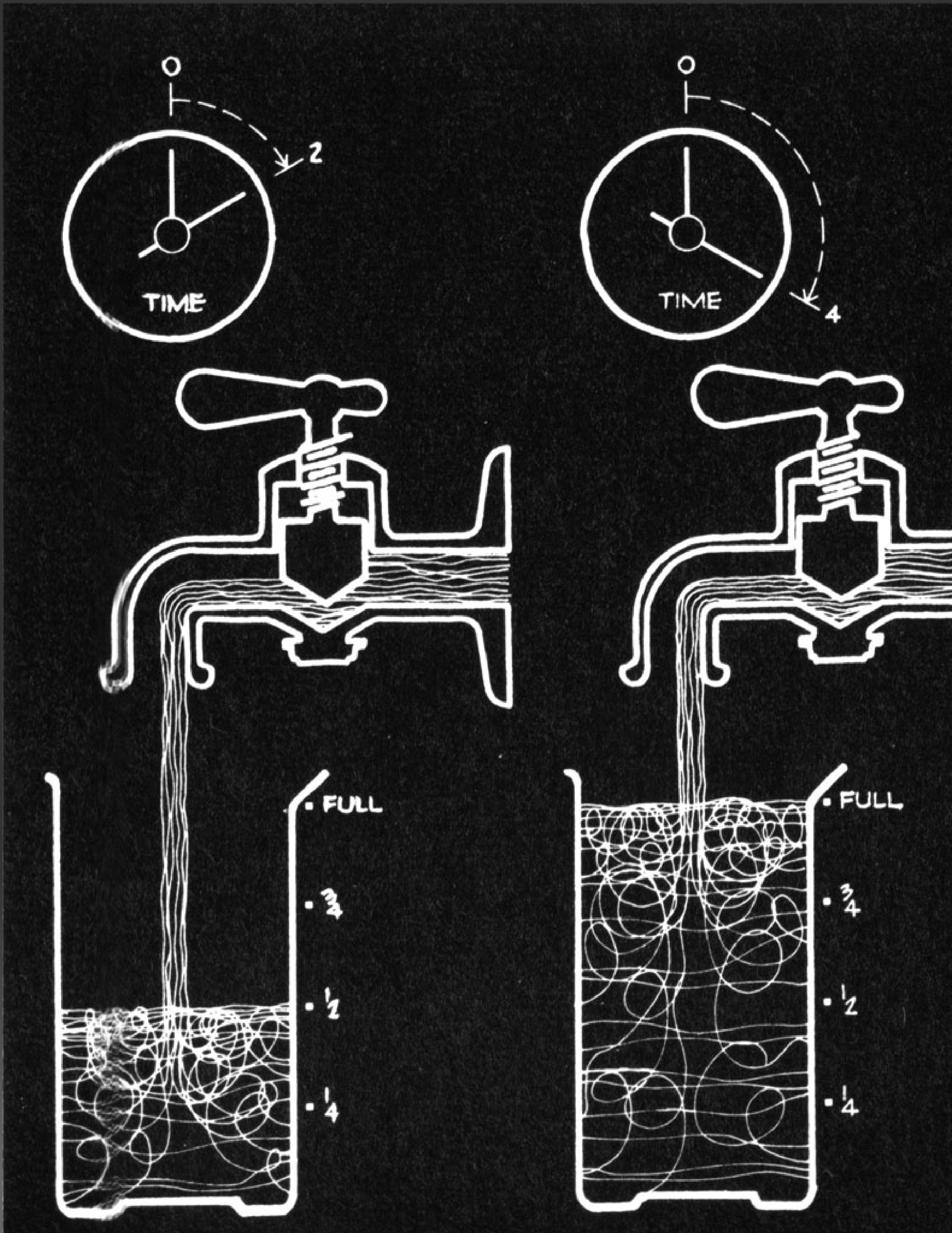
Here is an analogy to photographic exposure. The timer in this illustration represents the shutter speed portion of the exposure. The faucet represents the lens openings. The beaker represents the complete "filling" of the sensor chip or the film, or full exposure.

You can see that with equal "openings" of the "lens" (the faucet) the beaker on the left is half full (underexposed) in 2 seconds, and completely full in 4 seconds...

Also note that the capacity of the beaker is analogous to the ISO or light sensitivity setting on the camera. A large beaker represents a "slow" or less light sensitive setting, like ISO 100.

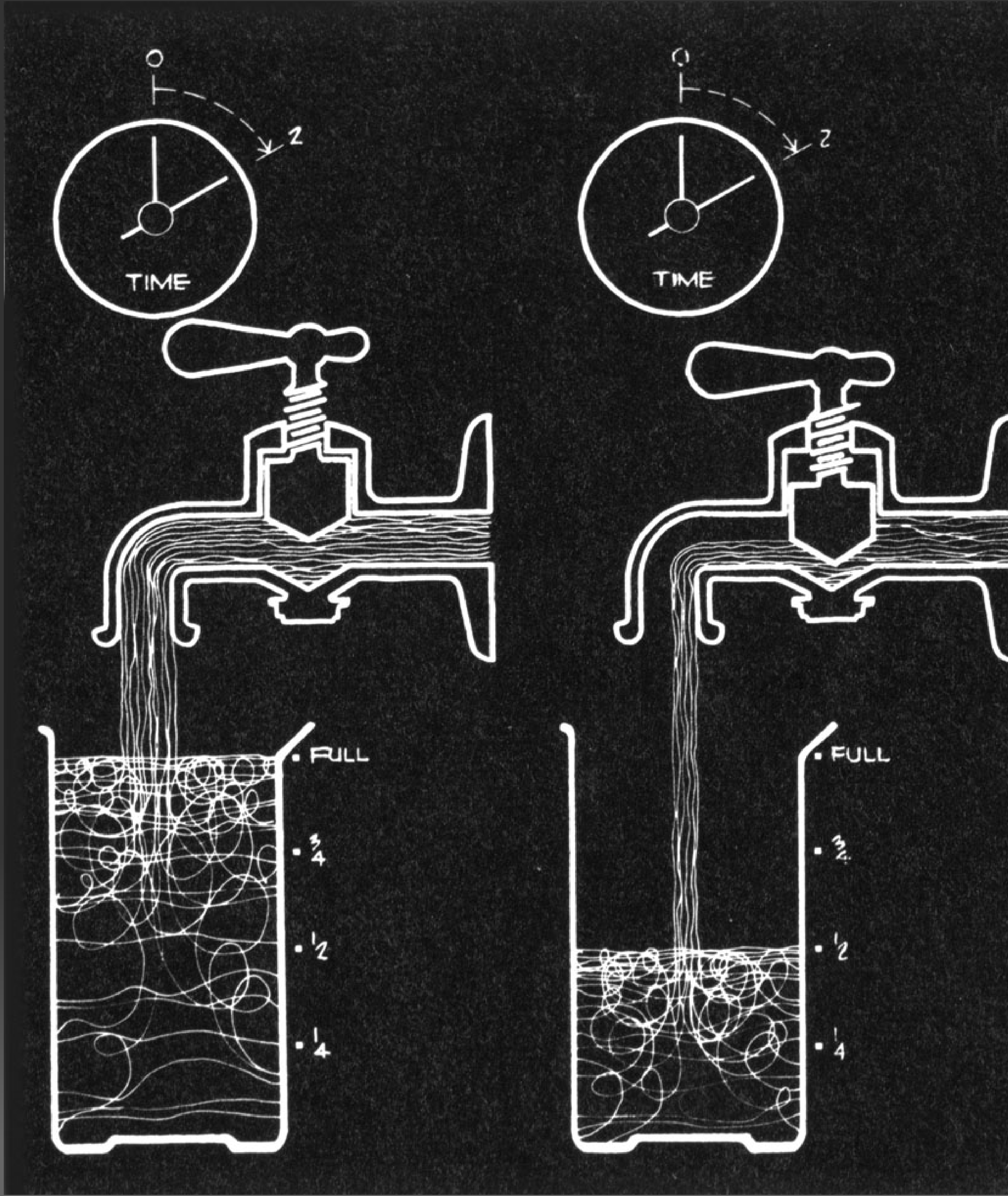
A small beaker is analogous to a "fast" or more light sensitive setting, like ISO 1200.

Doubling or halving the ISO number doubles or halves the sensitivity, effectively the same scheme as for f/stops and shutter speeds. 200 ISO film is "one stop faster" than ISO 100.



Equal Time
One f/stop down

In the second illustration, the example on the left, the faucet (lens opening, f-stop, or "aperture"- all the same meaning here) is opened twice as much as the example on the right- or one "stop." It passes twice as much light as the one on the right, in the same period of time.
Thus by opening the faucet one "stop," the beaker will be filled in 2 seconds. In the right example, with the faucet "stopped down" the film is underexposed by half- or one "stop." On the left, the "lens" is "opened by one stop."



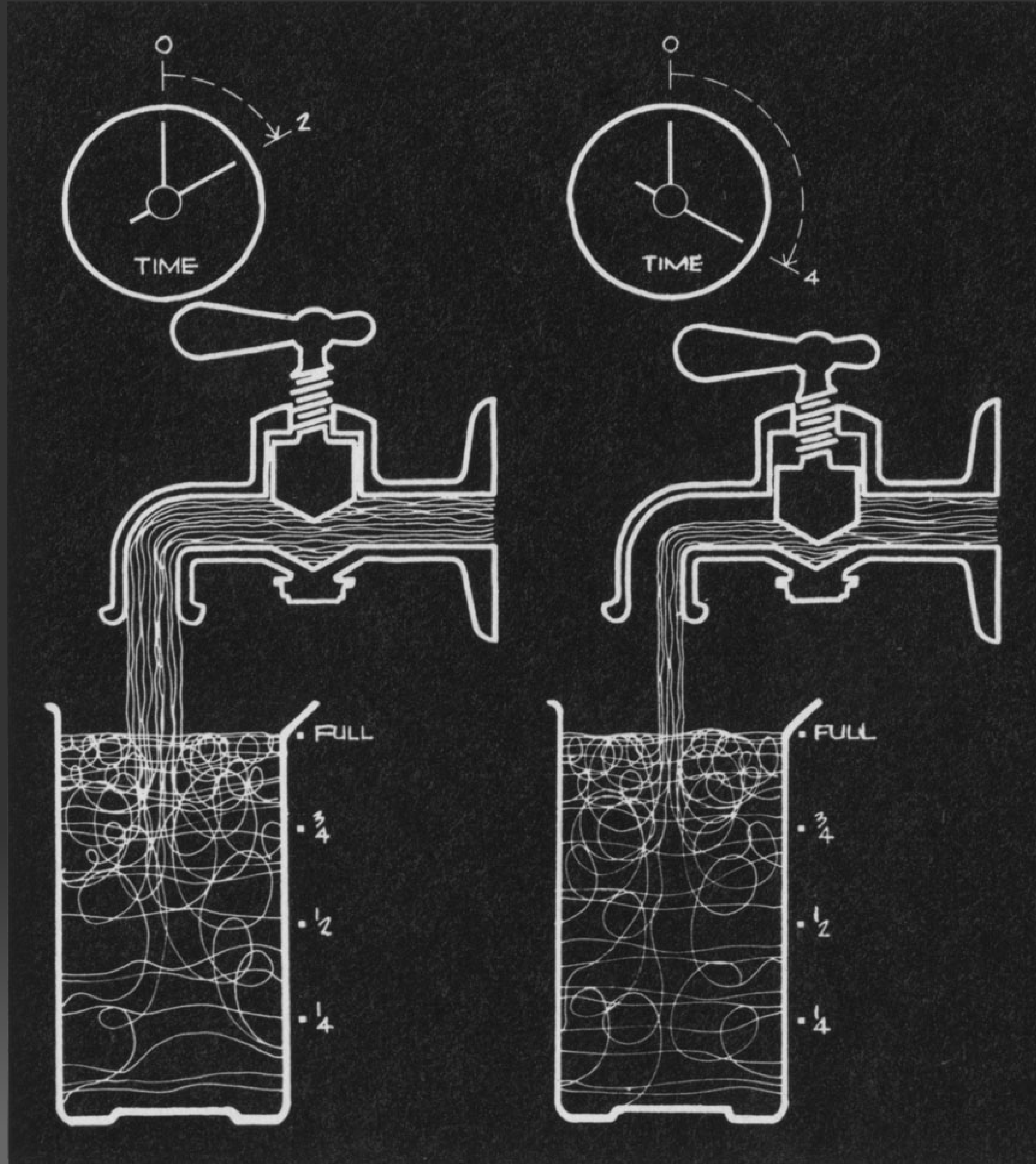
Equivalent Exposure:

Lens Open 1 f/stop more & 1/2 the Time

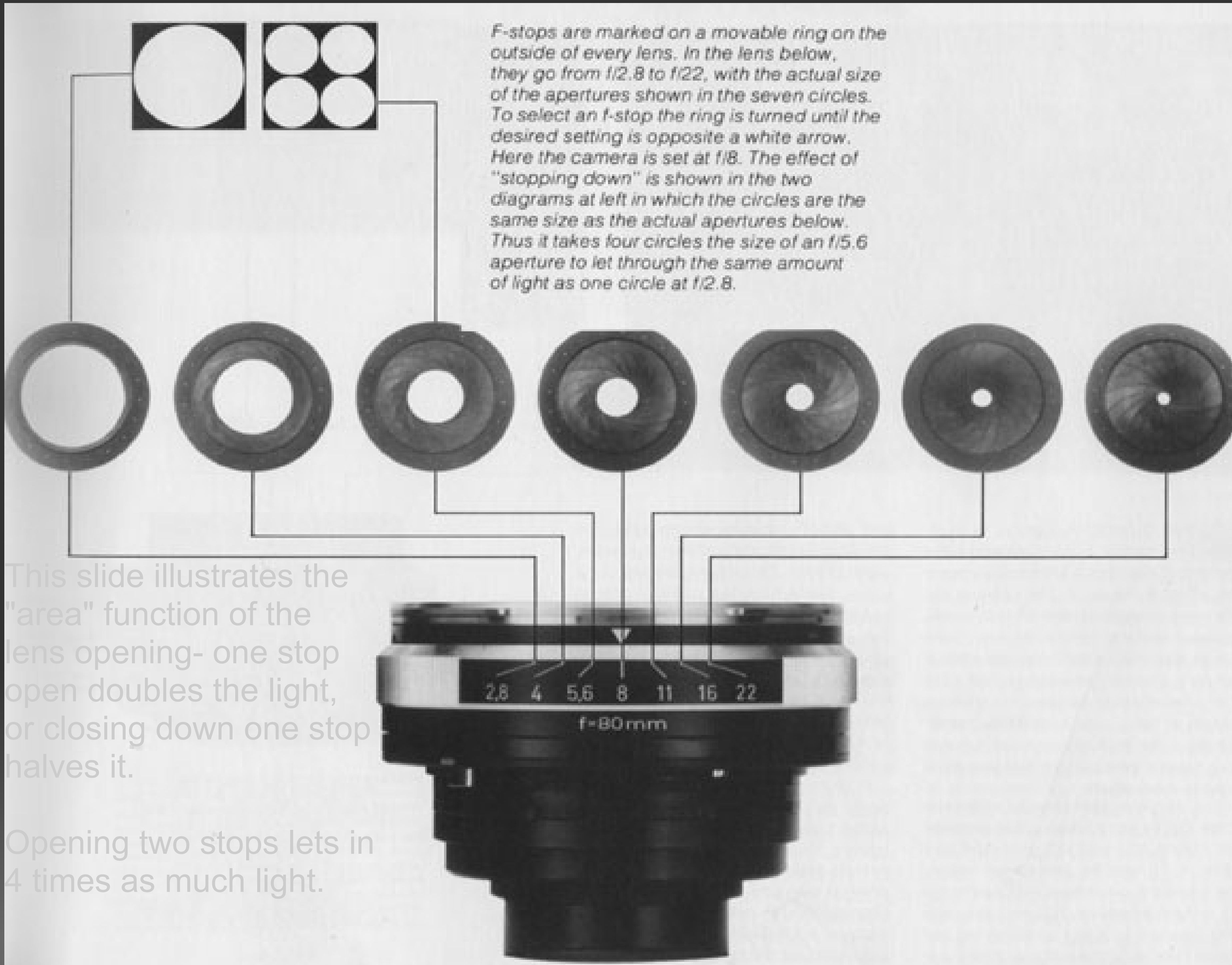
In this illustration, we have achieved "equivalent exposure" by, on the left, "opening the lens" by one "stop" exposing the sensor chip fully in 2 seconds.

On the right the lens in "stopped down" on f/stop from the example on the left, so to compensate for the reduced flow of "light' through the (one stop down) smaller aperture, we must double the time to 4 seconds.

The brightness of both images will be the same, because the sensor "saw" the same amount of light. It was just regulated differently. The effects on the rendering of time and the depth of field will be different.



"Stopping Down"



This slide illustrates the "area" function of the lens opening- one stop open doubles the light, or closing down one stop halves it.

Opening two stops lets in 4 times as much light.

What the markings on the lens mean:
"speed" is the widest aperture setting available on this lens, in this case f/1.9.

"focal length" essentially the magnification of the lens.

A "normal" focal length lens gives an image with a similar field of view as the eye-neither magnified nor reduced.

A "long" or "telephoto" lens magnifies the image, making distant objects look larger, while "seeing" a smaller angle of view.

A "short" or wide angle lens, "sees" wider angle of view than the human eye, while making objects within the frame smaller than they seem.

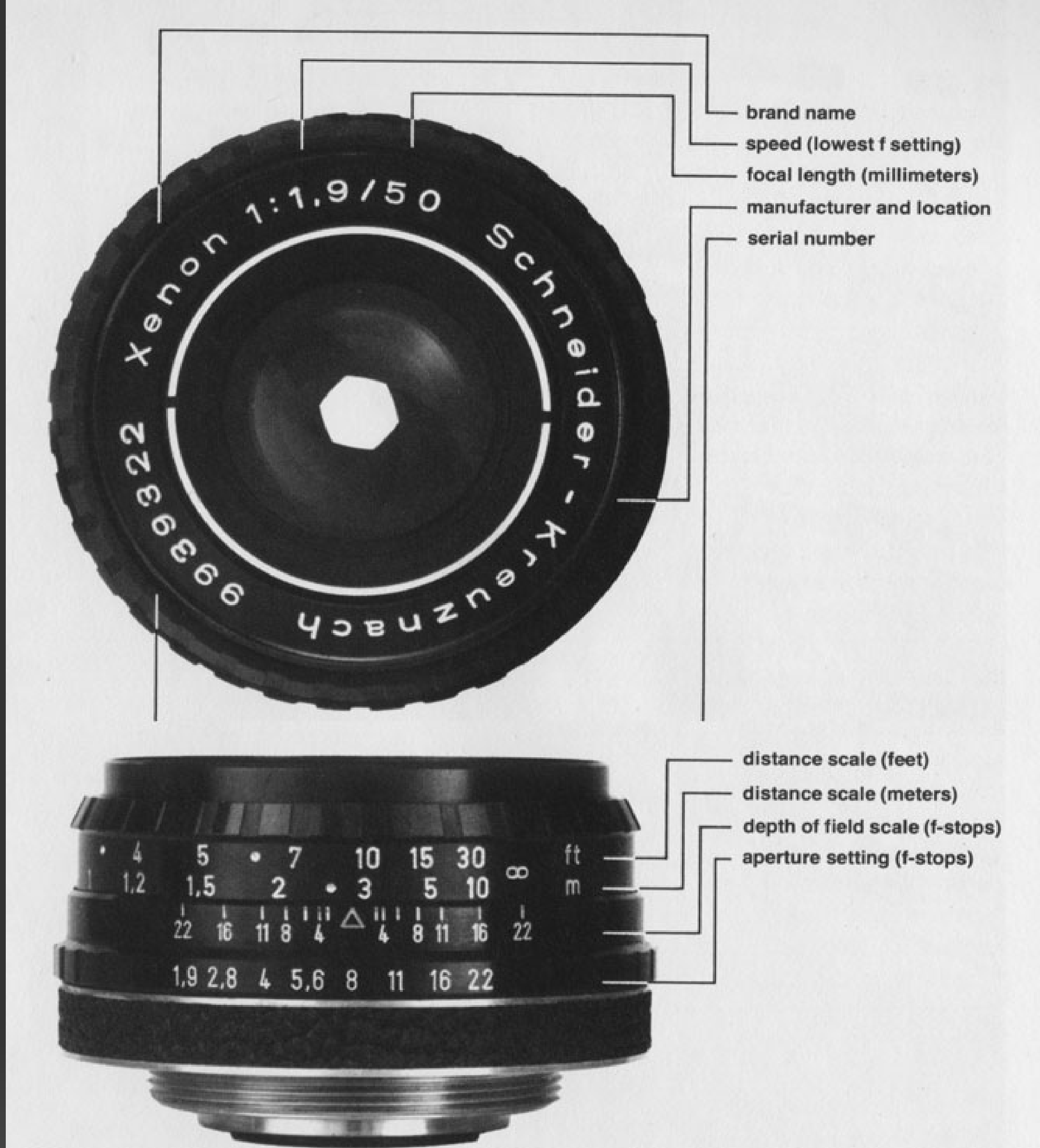
The distance scale indicates the distance, both in feet and meters from the camera to the point of focus. There is a triangular index for that distance on this Schneider lens. We are focused at a bit less than 10 feet or 3 meters.

Depth of field scale forms a bracket with the pairs of apertures on the scale, indicating the closest and furthest distance in "acceptable" focus, at a given distance and f stop setting.

In this case, at f/8 (and this focus point) from about 6.5 feet to 14 feet will appear "acceptably*" sharp.

The aperture (lens opening) is indicated on the inner ring, again with the triangle index mark above it.

*print size and viewing distance dependent.



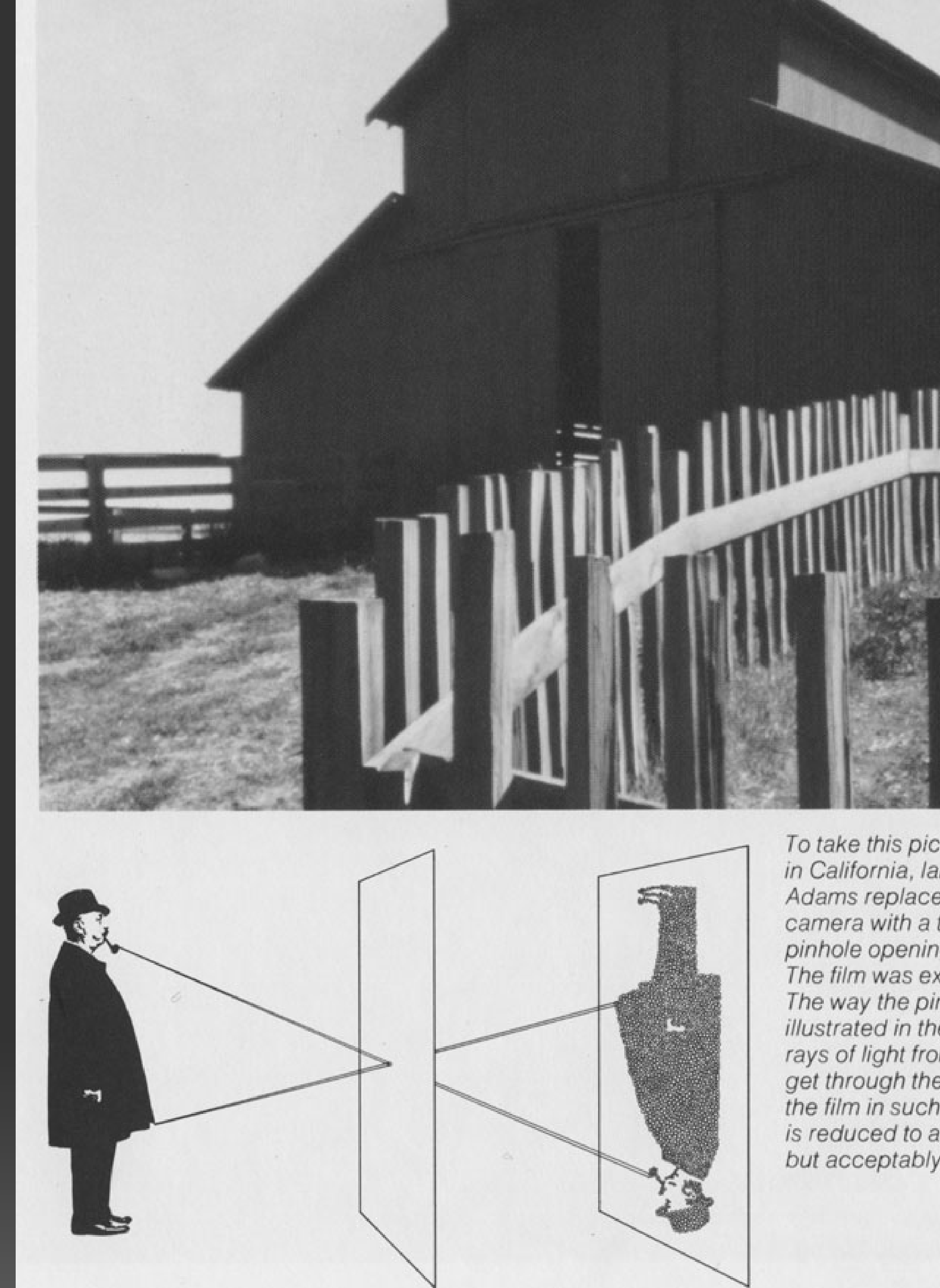
All the necessary information about a lens is marked on it, as these front and side views of the lens opposite show. On its front (top photograph) are its brand (Xenon), its speed (f/1.9), its size, or focal length (50mm), its maker's name and location (Schneider, Kreuznach, Germany), and its serial number (9939322). Distance and aperture scales are marked on the side of the lens.

A Pinhole Camera

A "Lens-less" camera.

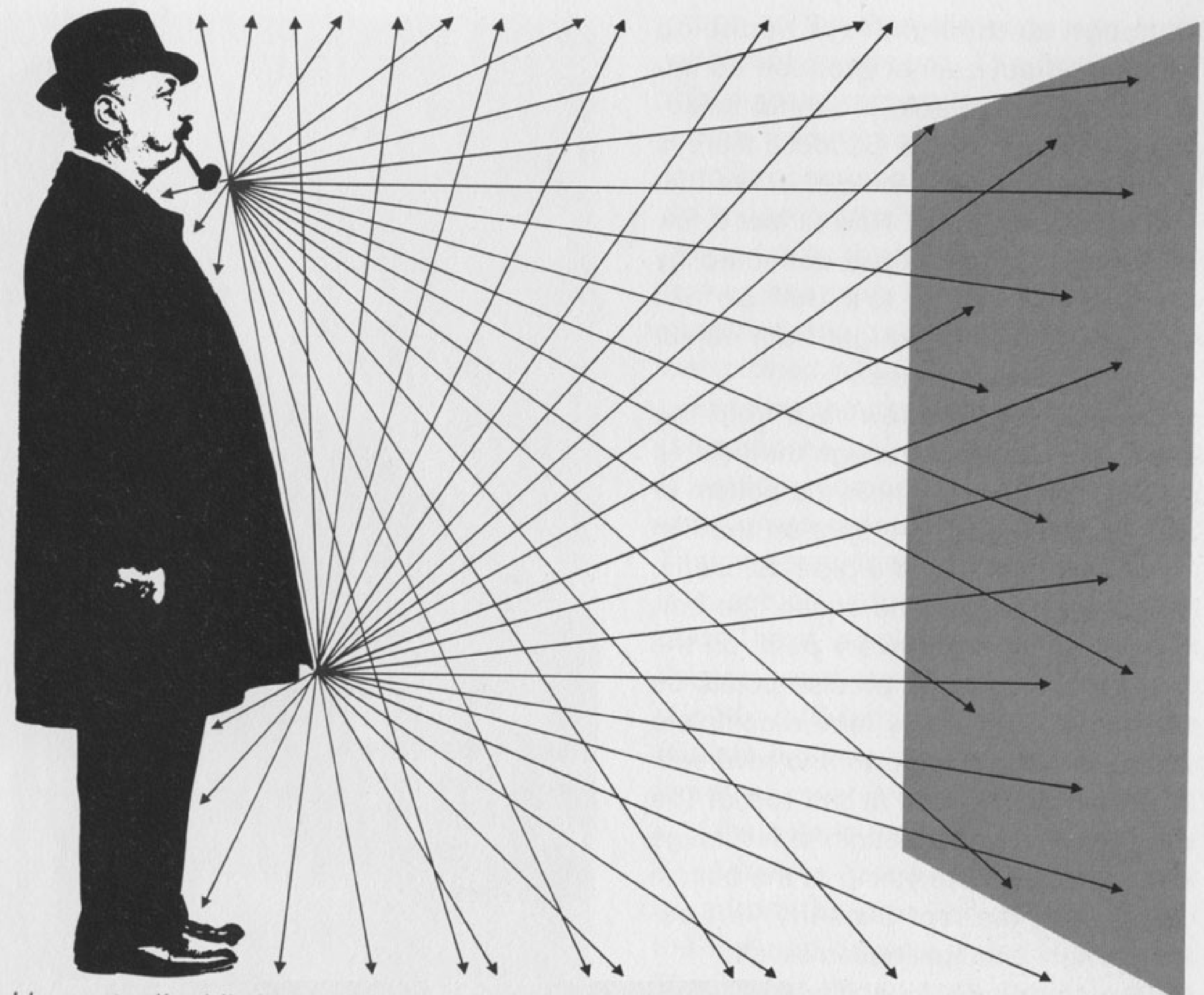
How a pinhole can form an image.

The *extremely* small "pin hole" opening only allows rays of light from a very small angle (reflected from the subject to the camera) to hit the film plane. Because the individual "circles of confusion" are so small, they combine to produce a fairly well focused image



Uncontrolled Light

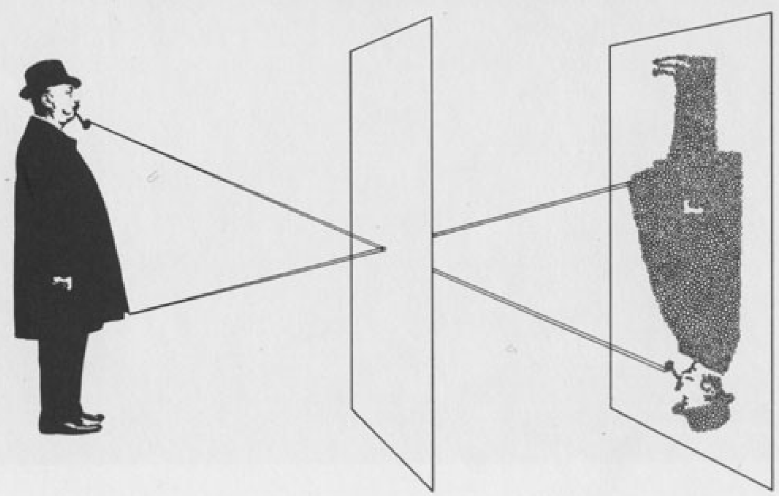
Light striking a subject, and reflecting from it in all directions. Without a pinhole to separate out the image forming rays of light, they reflect back to the "sensor" in an incoherent manner-forming no image.



Uncontrolled light rays, shown reflected from two points — the subject's pipe and the bottom of his coat — travel in almost all directions toward a sheet of film placed in front of the subject. Rays from the pipe strike the film all over its surface and so do rays from the coat; they never form an image of pipe or coat at any place on the film. The result is not a

A Small Pinhole Works Like a Lens

With the pin hole, the light rays are nearly parallel, or coherent, and thus form an image of the focal plane of the camera.

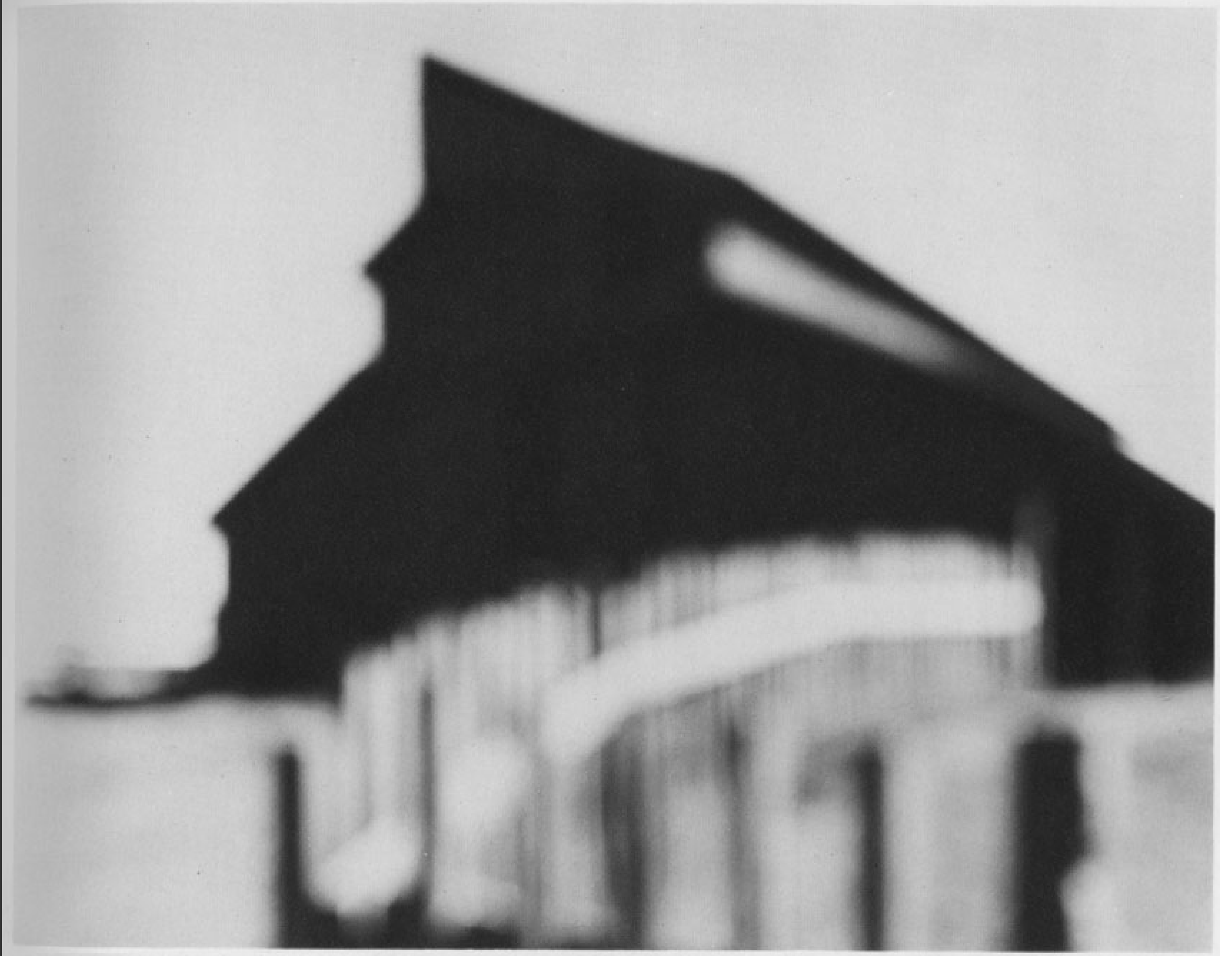


To take this picture of a fence and barn in California, landscape photographer Ansel Adams replaced the lens of an ordinary camera with a thin metal disk pierced by a pinhole opening 1/50 inch in diameter. The film was exposed for a full 6 seconds. The way the pinhole produced an image is illustrated in the diagram at left. Only a few rays of light from each point on the subject can get through the tiny opening and these strike the film in such tight clusters that blurring is reduced to a minimum. The result is a soft but acceptably clear photograph.

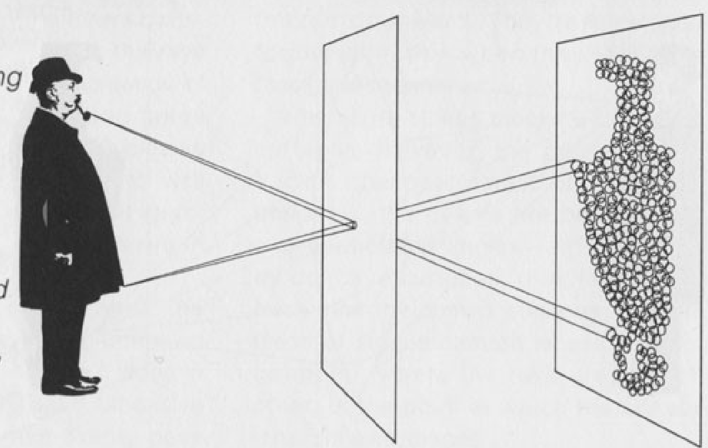
A Larger Pinhole

In this slide Adams increased the size of the pinhole, decreasing the exposure time to compensate for the increase in the passage of light through the bigger opening.

The circles of confusion are larger and overlap more, and thus the image looks less sharp.

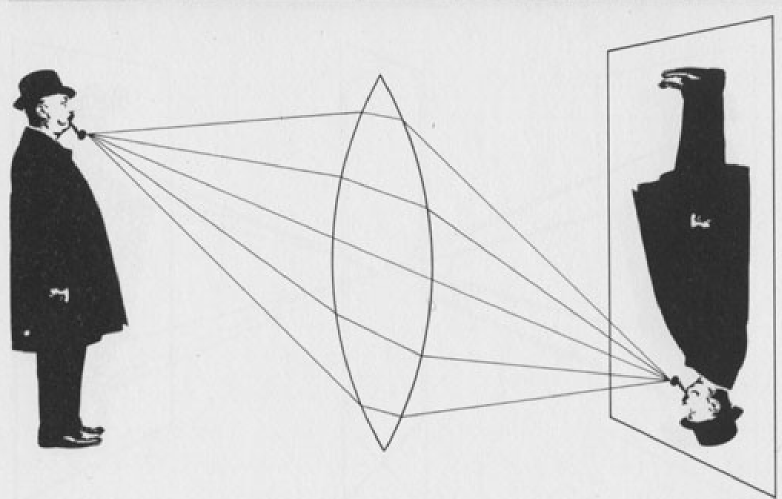


For a second photograph of the same scene, Adams increased the size of the opening to 1/8 inch, which meant reducing the exposure time to 1/5 second. The result is a hopelessly fuzzy picture. As shown in the diagram at right, the larger hole permits a greater number of rays from each point on the subject to enter the camera. These rays spread before reaching the film and are recorded as large circles. Because of their size, these circles tend to run into one another, creating a blurry photograph.



A Lens Replaces the Pinhole

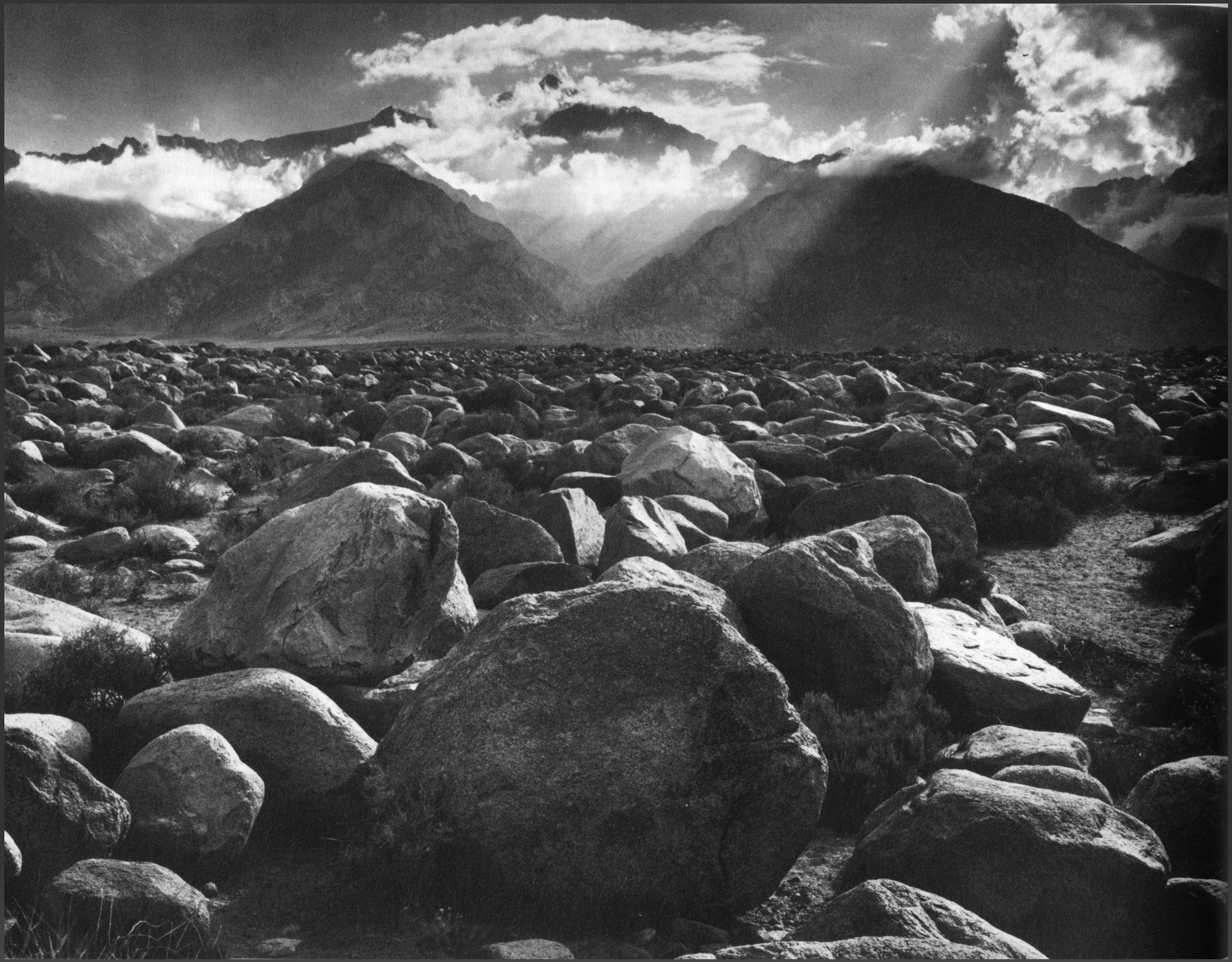
The same image, made with a lens, instead of a pinhole.
The lens "collects" the rays and redirects them to a single "focused" point on the film-creating a sharp image-at least at the point of actual focus.



Photographed this time through a convex lens, Ansel Adams' barn scene is as good as —or better than—the one on page 106 taken wi a pinhole camera. Most important, its exposure time, instead of being 6 seconds, was only 1/100 second. This is because the lens is much bigger than a pinhole and thus admits far more light. The diagram at left shows how the lens handles all this light by collecting many rays reflected from a single point and redirecting them to a corresponding single point on the film.

Ansel Adams
"Group f/64"
f/64 big number, small opening

An example of "great" depth of field.
The lens aperture was set at ~f/64 on Ansel Adam's view camera. That small of an aperture would require a longer shutter speed to compensate for the small amount of light passed through the tiny aperture.

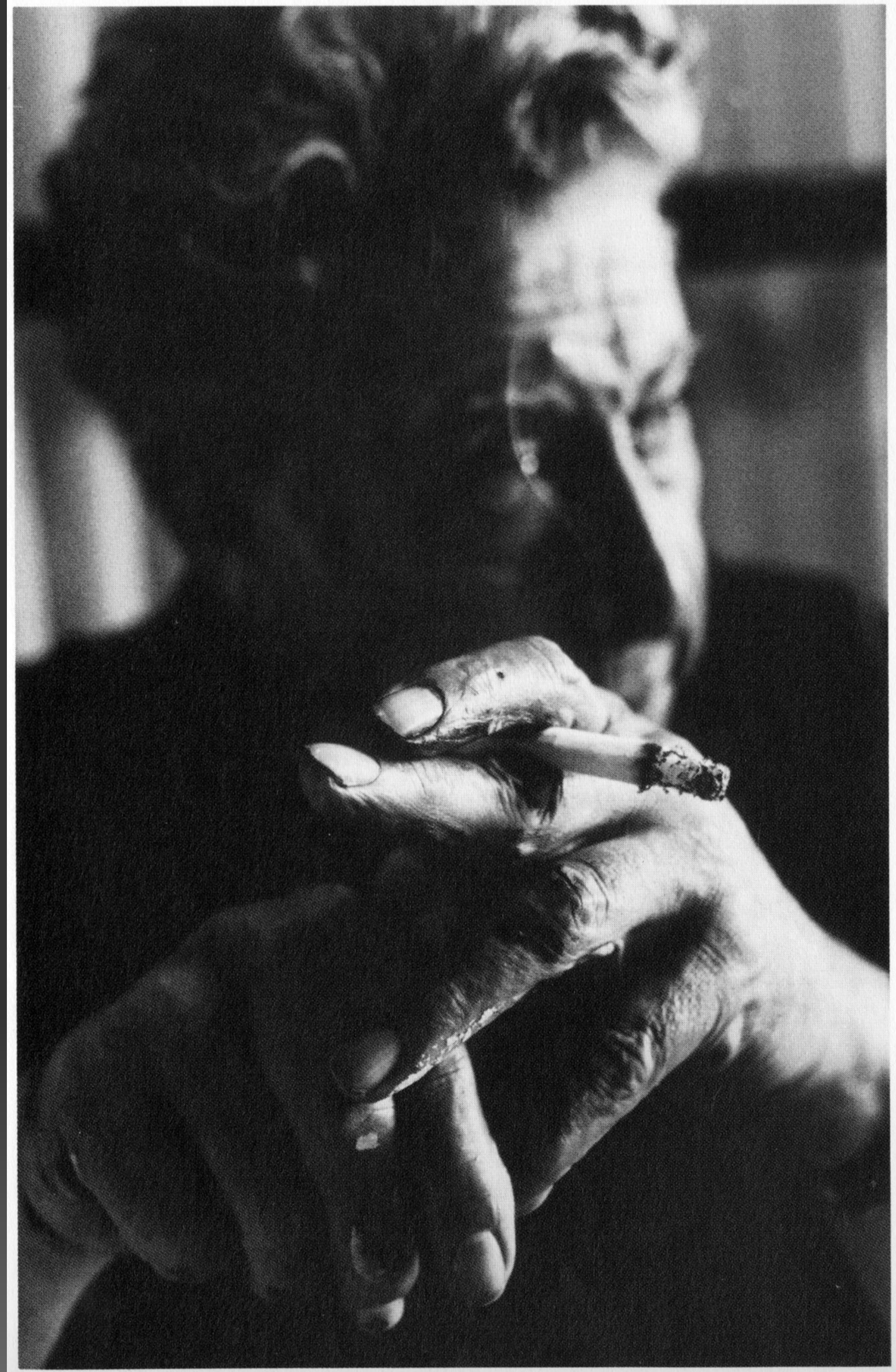


The very small circles of confusion from this small aperture make even the areas which are not in actual focus appear relatively sharp- creating "great depth of field."

Narrow Depth of Field

Here's an example of "narrow depth of field."

The large lens opening (wide aperture) leads to larger circles of confusion from the rays of light coming from the parts of the subject which are not on the plane of accurate focus. This creates a soft focus area and a sharply focused area-usually the main subject.



FARRELL GREHAN: *David Alfaro Siqueiros*, 1966

An image utilizing "narrow" depth of field. A small f/ number or "large aperture" perhaps f/4. This aperture is coupled with an appropriate shutter speed to achieve correct exposure, and motion stopping ability to "freeze" the Queen and her entourage.

MARK KAUFFMAN: *Princess Margaret Inspecting King's African Rifles, Mauritius*, 1956

Slow Shutter

WYNN BULLOCK: *Sea, Rocks and Time*, 1966

An image made with a slow shutter, perhaps 1 or more seconds. This long exposure allowed the parts of the field of view which were moving to be recorded blurry, while the static parts of the image recorded sharp.

A tripod or other camera stabilizing device must be uesd to assure that the still parts of the image are sharp. This effect would be ruined if there was camera motion, which would blur all of the image.

Fast Shutter

A creative use of fast shutter. The short-perhaps 1/1000 second effectively stopped the motion of the boy jumping.

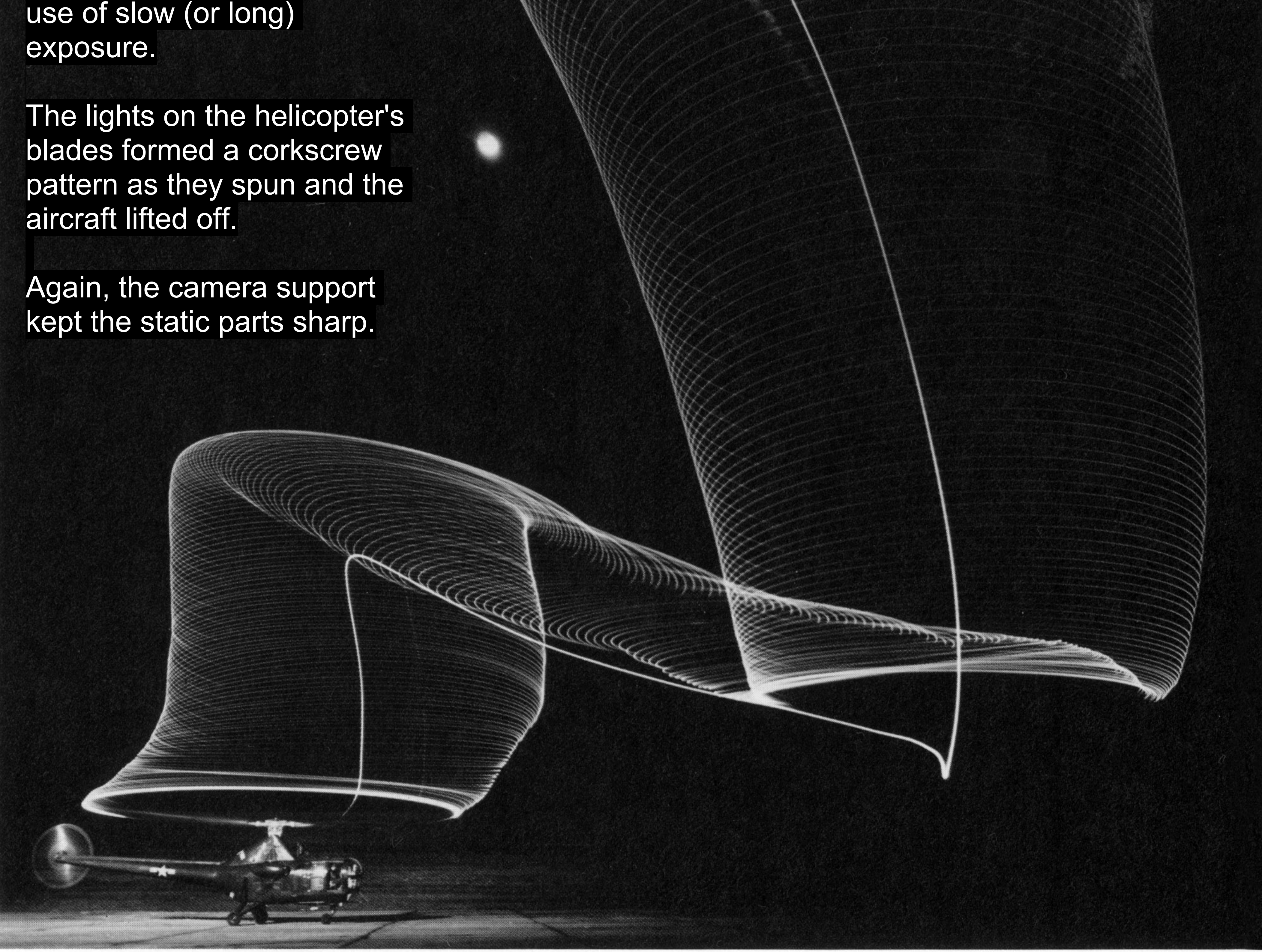
Note that the fast shutter's effect on exposure (less light) was offset by using a larger aperture, which causes the distant, unfocused objects to record blurred-narrow depth of field.

FREDRIC WEISS: *Boy Jumping*, 1968

use of slow (or long) exposure.

The lights on the helicopter's blades formed a corkscrew pattern as they spun and the aircraft lifted off.

Again, the camera support kept the static parts sharp.



Ralph Crane used a slow shutter, effectively "panning" from another moving car, making the main subject sharp, while allowing the impression of motion to be created by the blurry, "moving" background.

RALPH CRANE: *Hot Rodders*, 1949