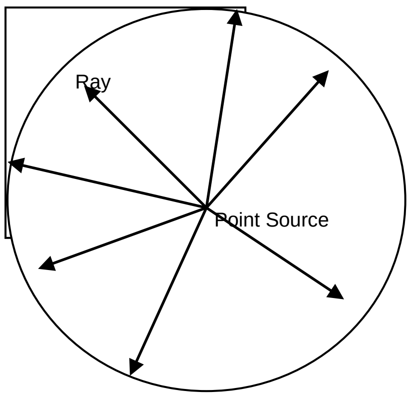
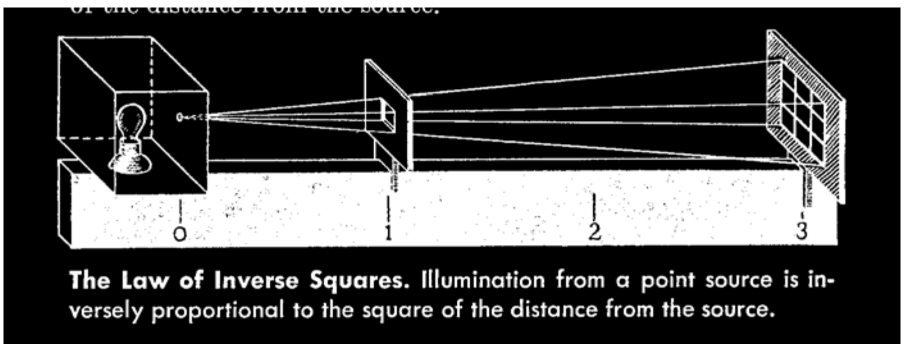


POINT SOURCES, RAY TRACING, AND INVERSE SQUARES

When light escapes from an ideal *point source*, it travels in all directions with an equal intensity[1]. These paths are considered to be the radii of a sphere with the source at the center. This is why light is said to *radiate* from a source, and why it's considered to be *radiation*.

Intensity of the light will be strongest near to the source, and it falls off with distance. The attenuation is predicted by the **Law of Inverse Squares**.



The Law of Inverse Squares. Illumination from a point source is inversely proportional to the square of the distance from the source.

Here it is shown that the intensity of the light at 3 Units from the source is $1/9^{th}$ of that 1 Unit from the source, as the area of the square that is being investigated close up has grown 9 times larger as the distance from the source has grown by a factor of 3. At 2 Units distance, the area becomes 4; at 4 Units distance, the area has become 16. Since the same amount of light contained in one square is now spread out over 16 squares, each square now only contains $1/16^{th}$ of the original intensity. The amount of attenuation would be written in an equation form as $1/r^2$, r being the distance (radius of the sphere) from the light source.

APPLICATIONS OF THE INVERSE SQUARE LAW:

When it comes to the monster light source, the sun, we don't really feel the effects of the inverse square law even when photographing outdoors at street level or on a roof top, since even a few hundred feet is not a big percentage compared to the distance from the sun, 93 million miles. It is a big deal for the inhabitants of Mercury, whose distance from the sun is about 23 million miles, so the intensity there is about 16 times as bright as here on earth! No wonder its atmosphere has boiled off!

Going away from the sun, like a probe going to Saturn, whose distance is about 370 million miles from the sun, the intensity drops to less than 1/100 of that here,

[1] Practically light never radiates in a true hemisphere, as there is always a bulb base, and/or a reflector.

requiring big batteries or other power supplies instead of solar cells like satellites in earth orbit.

For artificial lighting in a studio, exposure times can be shortened by moving objects closer to the light source. Every time the object-illumination distance is halved, the exposure time can be quartered. This can be uncomfortable for some subjects. By moving fill lights nearer to or farther away from the subject, the lighting ratio can be controlled within limits.

Camera mounted flash units live and die by the inverse square law. The farther the subject the subject is from the camera/flash combination, the less light it receives. The exposure mechanism on the camera needs to compensate for this discrepancy

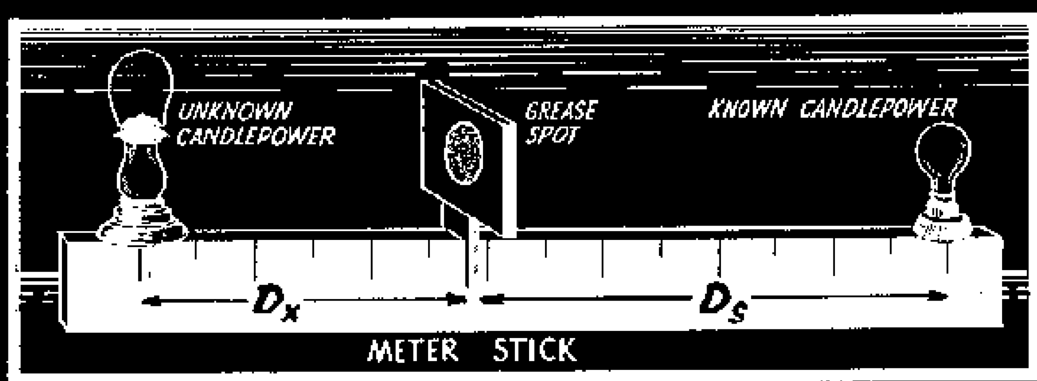
In the old days, when flash bulbs ruled, each different size of bulb had a *guide number*. The photographer would measure the distance from the subject to flash, or relied on the rangefinder on the camera to tell the distance, divide that distance into the guide number, and the quotient would give the approximate f/stop to shoot at. For example, for an M2B bulb, guide number of 60, a subject 5 feet away would require an aperture of f/12, with f/11 being the closest marked one.

This brutal practice continued even into the early electronic flash era. In the seventies a circuit incorporating a photo cell aimed at the subject drank in the light reflected from the scene, and turned off the flash when it had its fill. The strobe would be on for shorter times for nearer objects, and longer for further ones until the full amount of light that could be pumped out of the flashtube was used up. This system worked well as long as the lens was set to the proper f/stop recommended by the strobe for the speed of the film being used. In some contemporary cameras a photo cell monitors the light as it hits the film during the exposure to control the flashtube's duration.

A CLEVER USE OF THE INVERSE SQUARE LAW:
When Edison was making his early electric light bulbs, there were no commercially available light meters. Illustrated below is a *Grease Spot Photometer* that was used to measure the brightness of an incandescent bulb as compared to a candle.

The operator would look into the eyepiece, which was borrowed from a stereo photograph viewer. They would observe a piece of paper that has a circle in the center which was greased to become translucent.   A position was found when the grease spot was moved from side to side where it seemed to disappear thanks to the intensity from both sources being equal. By comparing the squares of the distances the relative intensity of the two sources could be found. In this case, the output of the incandescent bulb could be measured relative to a standard candle!

From an Edison Building at Henry Ford's Greenfield Village



The Bunsen Photometer. When the grease spot disappears, the candle powers of the lamps are directly proportional to the squares of their distances from the spot.

Well, maybe Edison didn't invent it, but certainly used it!