CHAPTER XII.

HOW TO MAKE PHOTOGRAPHS

THE art of photography is made up of three parts: light, optics, and chemistry. This may be explained by saying that light either coming directly from an object or reflected by it and made to pass through a lens of the proper kind, will form an image of the object on a flat surface, and if this is chemically prepared, the image can be fixed there and a picture, or *photograph*, as it is called, is thus made.

What Light is. In order to know how light acts, you must know something about its nature. In Chapter XI I told you that when a substance burns it gives out light; that the vibrating molecules of a burning substance set the ether into motion, and that it is by, in, and through the latter that *light-waves* travel. Now the two following analogues will make clearer what light and light-waves are: First, you have often noticed that when you throw a stone into a pool of still water, little ring-like waves, or circular ripples, will be formed around the place where the stone has struck the water, and these will expand until either their energy is used up or they are stopped by the shore. In other words, the stone sends out *water-waves*, as shown in Fig. 144.

Now, to go a step farther, if you strike a bell it *vibrates*, that is, the rim of it moves rapidly to and fro, as shown in

Fig. 145. These rapid movements are imparted to the air and set up waves in it, and while these are really air-waves, they are called *sound-waves.* These waves spread out in every direction and keep on expanding until they either strike some object and are reflected by it, or their energy is used up by in overcoming friction and other resistances.

Finally, if you ignite a substance that will burn, as, for instance, a candle, the heated molecules given off by it will be thrown into exceedingly rapid *vibration*, that is, a rapid

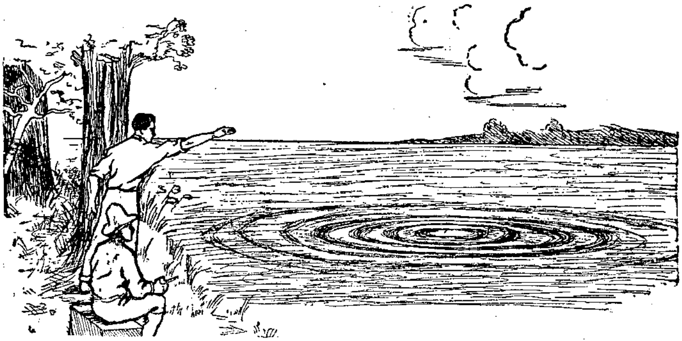

FIG. 144.—How a Stone Sends Out Water Waves.

to-and-fro motion, and these will set up waves in the ether which are called *light-waves*, see Fig. 146, but which are really only *ether-waves.* Like water-waves and sound-waves, light-waves are radiated in every direction, but normally travel in straight lines, and they keep on going until they are stamped out by the resistance they meet.

How Light Acts. Suppose you closed your eyes and that you held a string with a cork tied to it, and resting anywhere on the surface of the pool of water into which a stone was thrown. When the water-waves were sent out by the impact of the stone you would be able to sense their presence by the pull of the string every time the wave made the cork bob up and down, and the sensation of touch would by carried by the afferent nerves to your brain.

So in a like, but very much more refined way, wherever you may be, as long as you are within earshot of the sound-waves sent out by a bell, they will impinge on your ear, and

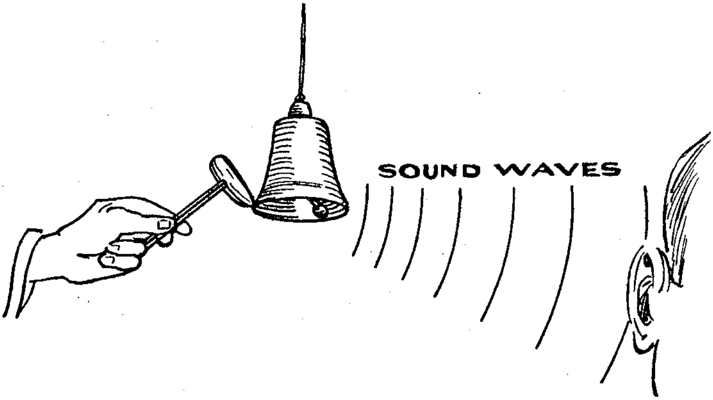

FIG. 145.—How a Bell Sends out Sound-Waves.

the auditory nerves will convey them to your brain, where the sensation of sound is set up. Likewise, wherever you may be within range of the light-waves sent out, or reflected, by an object, the lens of your eye will form an image of it on the retina, and the optic nerves will transmit it to your brain, where the sensation of light, of form, and of color is produced.

Now light not only acts on the eye so that we are able to see the images it forms, but it has a decided action on the growth of plants in that it builds up compounds in and for them; thus it makes the green coloring-matter of plants, called chlorophyl, and the action of light on this compound forms formaldehyde (CH_2O), which is a gas with a stifling odor, and this in turn is converted into sugar($C_{12}H_{22}O_{11}$). Not only plants but animals must have light in order to grow and, hence, its action on these bodies is to build up their tissues. While the action of light on plants and animals cannot be seen, there are compounds that break down,

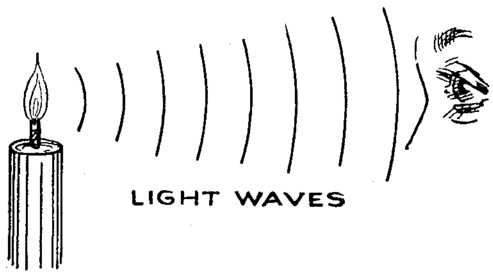

FIG. 146.—How a Candle Sends out Light-Waves.

that is, they are decomposed, when exposed to it, and the effects of these are very readily observed.

How Light Acts on Silver. Of all the compounds that light has been found to act upon, those formed of silver (Ag) are the most sensitive, and for this reason they are used in photography. Of these salts, silver nitrate ($AgNO_3$), silver chloride ($AgCl$), and silver bromide ($AgBr$) are the most easily affected. Silver nitrate ($AgNO_3$) was the first salt that was found to break down under the action of light, and then followed silver chloride ($AgCl$), which is still more sensitive, and, finally, silver bromide ($AgBr$), which is the most sensitive of all.

How to Make Silver Nitrate. Silver nitrate ($AgNO_3$), which used to be called *lunar caustic*, is the starting-point for making the other salts of silver (Ag). To make a few crystals, put 2 fluid ounces of pure water (H_2O) in a beaker, then add ½ fluid ounce of nitric acid (HNO_3) to it and drop a bit of pure silver (Ag) the size of a dime into the solution. Stir it with a glass rod, and when the silver (Ag) has dissolved let it stand and crystals of silver nitrate ($AgNO_3$) will be formed, nitric oxide (NO) gas will pass off, and the liquid left behind will be water (H_2O) thus:

$$\underset{\text{Silver}}{3\,Ag} + \underset{\text{Nitric acid}}{4\,HNO_3} = \underset{\text{Silver nitrate}}{3\,AgNO_3} + \underset{\text{Nitric oxide}}{NO \uparrow} + \underset{\text{Water}}{2\,H_2O}$$

Experiments with a Silver Nitrate Solution. Nearly fill a clean 2-ounce bottle with distilled water (H_2O), drop in the crystals of silver nitrate ($AgNO_3$), put in the cork, and shake until the crystals are dissolved. If, now, you will place the bottle where the light of the sun will fall on it, no chemical action will take place and the solution will remain colorless. Now take a sheet of paper, pour the solution over it and expose it to the light of the sun, and you will find that the light will quickly act on it and turn it a brown color.

The question is why will not the light act on the solution when it is in the bottle as it does when it is spread out on the paper. The answer is because light will decompose the salts of silver (Ag) only when the latter is in contact with *organic matter*. By organic matter is meant plant or animal matter that is living or has once lived. Paper, as you know, is formed of cellulose ($C_6H_{10}O_5$), and it is of this compound that plants are largely built up.

How to Make Silver Chloride. Dissolve 1 teaspoonful of sodium chloride ($NaCl$), that is, common table salt, in a test tube full of water (H_2O), then dissolve the same amount

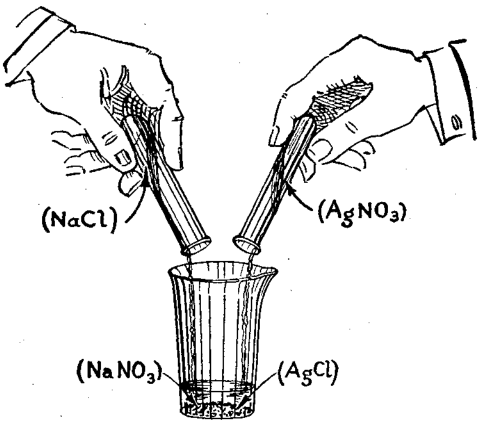

FIG. 147.—How Silver Chloride is Made.

of silver nitrate ($AgNO_3$) in a test tube one-fourth full of water. After the salts have dissolved, pour the solutions of both test tubes into a beaker, as shown in Fig. 147, and stir them together with a glass rod, and a milky-white precipitate will be thrown down, which is silver chloride ($AgCl$). The reaction is called a double decomposition, in which the silver (Ag) of the silver nitrate ($AgNO_3$)

changes places with the sodium (Na) of the sodium chloride ($NaCl$), and it may be expressed thus:

$NaCl$	+	$AgNO_3$	=	$NaNO_3$	+	$AgCl \downarrow$
Sodium chloride		Silver nitrate		Sodium nitrate		Silver chloride

The next thing to do is to put a sheet of filter paper in a glass funnel and then set this in a bottle; now pour the solution with the precipitate into the funnel. The solution will run through it and the precipitate will remain behind.

Action of Light on Silver Chloride. Put a tablespoonful of water (H_2O) in a test tube, and after scraping the silver chloride ($AgCl$) from the filter paper spread it over a sheet of unglazed paper and let it dry. If, now, you will expose it to the light of the sun you will see that it turns a purplish color first, then gets brown, and finally black.

Evidently the light has produced a change in the silver chloride ($AgCl$), and, in truth, it has acted on it in such a way that the compound has broken down into the two elements of which it was formed, namely, silver (Ag) and chlorine (Cl), as the following equation shows:

$AgCl$	+	*Light*	=	Ag	+	$Cl \uparrow$
Silver chloride		Light		Silver		Chlorine

The chlorine (Cl), which is a gas, passes off, and the very fine brown, or black, film that remains behind is formed of minute particles of pure silver (Ag). It is this action of light on silver compounds that makes it possible to take a picture on a glass plate, a celluloid film, or a paper sheet; there are, however, other operations necessary, the chief one being to fix the picture so that it will not fade out, and this will be described presently.

How to Make a Pinhole Camera. To understand how light forms a picture, or *image*, as it is more properly called, of an object, we shall have to leave the *chemistry* of it for the moment and get into the *physics* of it. The simplest way is to make a *pinhole camera*, by means of a pair of open-end, rectangular pasteboard cases, each of which is, say, 4 inches wide and high and 6 inches long, so made that one will slide snugly into the other, as shown in Fig. 148.

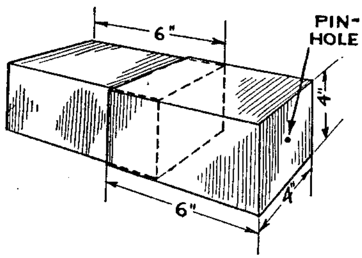

FIG. 148.—How to Make a Pinhole Camera.

Now glue a thin disk of cardboard over one end of the larger case and make a pinhole in the center of it, and then secure a sheet of oiled tissue paper over one end of the smaller case and slide them together. Your pinhole camera is then ready to use. Hold it in a line with the object the image or picture of which you want to see on the *screen*, as the oiled tissue paper is now called, and *focus* it, that is, slide the smaller case in or out until the image on the screen is as sharp as you can get it.

How the Camera Works. You will observe that, curiously, the image on the tissue paper is *reversed*, that is, it is upside down, but the reason for this will be clearly understood by a look at the diagram shown in Fig. 149. Now light-waves travel in straight lines and they are sent out in every direction from every point of a candle or other object, but of all the waves sent out from a particular point, as for instance the one marked A, only those will go through the pinhole, B, that are in a straight line with it, and then they pass on to the screen, where they strike it at C. In the same way, only the waves from the point marked D can get through the pinhole, B, that are in a straight line with it, and these impinge on the screen at E; and this is true of all other parts of the candle or other object.

How a Real Camera is Made. A real camera differs from the one just described in that it has a lens instead of

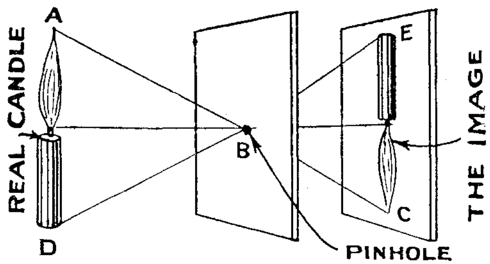

FIG. 149.—How the Image is Reversed.

a pinhole in the front part of it, and either a *plate-holder* to hold the sensitized glass *dry plate*, or a *roll-holder* to carry the spools, where *films* are used. A cross-section of a real camera is shown in Fig. 150. By using a lens in a camera, a great deal more light can be got through it than through a pinhole, and this makes for speed of exposure, and, further, and what is equally important, the image is very much more clearly defined.

How Dry Plates and Films are Made. To make a dry plate or a film so that it will be sensitive to the light and free from pinholes and spots is an expert's job, and he must have a specially equipped laboratory for the purpose. However, I will tell you how it is done and you can try to make them just as I did when I was a boy of your age, only I had the decided advantage of having worked for a dry-plate manufacturer.

Now just as silver chloride ($AgCl$) is more sensitive to light than silver nitrate ($AgNO_3$), so silver bromide ($AgBr$)

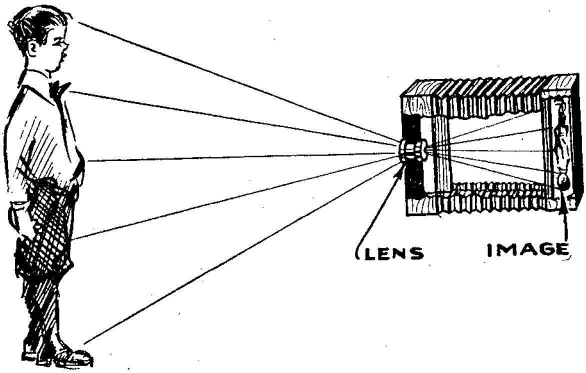

FIG. 150.—How a Real Camera Works.

is more sensitive than silver chloride ($AgCl$). You can make enough silver bromide ($AgBr$) *emulsion* to coat a dozen 4 by 5 glass plates in this way: put 1 ounce each of silver nitrate ($AgNO_3$) and ammonium bromide (NH_4Br) in a beaker, with enough water (H_2O) to dissolve them; now put 2 ounces of clear gelatine, which is an organic compound, in the beaker with enough water (H_2O) to cover it; gently heat them over the flame of your alcohol lamp until