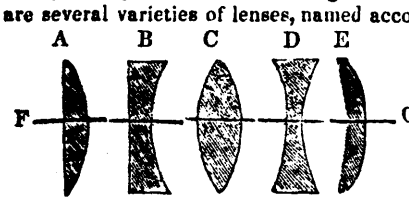
tains and clouds, are distinctly delineated. (Can chance be the author of such an instrument ?) —A *concave* mirror is curved inward, and reflects from the *hollow* surface, and its powers, as its shape, are the reverse of those of the convex mirror.—Though we have figures to illustrate what is here stated in respect to *mirrors*, we have not room for them and the requisite explanations at present. In the spherical parts of brass andirons, or silver spoons, we have *convex mirrors*, with which children frequently amuse themselves in viewing their own miniature likenesses: while in the concave or hollow parts of silver cups or spoons we have *concave mirrors*, which correspondingly magnify the images of objects reflected by them. It will therefore be recollected that *concave mirrors* collect the rays of light, and magnify objects—that *convex mirrors* disperse the rays of light and diminish objects—that *plane mirrors* reflect rays of light without either enlarging or diminishing the visual angle, and consequently represent objects of their natural size.

6. Lenses.—Lenses, on account of their extensive use in the construction of optical instruments, from the microscope up to the telescope, require more particular notice. Glass, in various forms, is the substance most used for these purposes, which owing to the peculiar form of the lens, causes the rays of light to converge to a focus, or disperses them according to the laws of refraction. There are several varieties of lenses, named according to their focus. Five of these varieties are represented in Figure 5. It will be seen that they all represent portions of the internal or external surface of a sphere. A represents a *single or plano convex lens*, which is bounded by a plane surface on one side and a convex one on the other, or in other words, is flat on one side and convex or oval on the other. B represents a *single* or *plano concave lens*, which is flat on one side and concave or hollow on the other. A *double concave lens* is concave or hollow on *both* sides, as represented by D. C represents a *double convex lens*, which is bounded by two convex or spherical surfaces. Their centres are, of course, on opposite sides of the lens. E represents a *meniscus*—a word derived from the Greek, literally signifying *a little moon*. The term is applied to this kind of *concavo-convex* lens, from its similarity to the young moon. As all the lenses are portions of the internal or external surface of a sphere, their *axis* is a straight line, F G, passing through their centre.



(Fig. 5.)

7. The peculiar form of the various kinds of lenses, causes the light which passes through them to be *reflected* or *bent* from its straight course, according to laws which we briefly explained last month. According to these laws, it will be recollected, light passing from a rarer to a denser medium is *refracted* or bent *towards* the perpendicular; and, on the contrary, passing from a denser to a rarer, it is refracted or bent further *from* the perpendicular. Now, it will be seen, from the straight line F G, *Fig.* 5, that a perpendicular to any convex or convave surface, must, when prolonged, pass through the centre of sphericity—or, in other words, the centre of the sphere of which the lens is a portion. It therefore follows, according to the laws just stated, and the situation of the perpendicular on each side of the lens, that a *convex lens* (contrary to convex mirrors) collects the rays into a focus, and magnifies objects at a certain distance; while *concave lenses* (contrary to concave mirrors) disperse the rays and diminish the objects seen through them.

8. The *focal distance* of a convex lens is the distance from the centre of the glass to the point at which the rays of light passing through the lens converge. This depends upon the convexity of the lens. The more convex the glass is, or in other words, the more the thickness of the middle exceeds that of the extremities, the shorter will be its focal distance; or the nearer to the glass will the rays passing through it be converged to a point. This point is easily ascertained by experiment, and may be accurately stated in any given case. It has been remarked, that a convex lens is a portion of a sphere. The sphere of a lens, then, is an imaginary circle of the surface of which the lens is a portion. The *radius* of a lens is, therefore, the radius or half the diameter of this sphere. Now, the focal distance (or the point beyond the lens where the refracted rays meet) of a plano-convex lens, is equal to the diameter of its sphere, and the focus of a double-concave lens is equal to the radius, or half the diameter of its sphere. The less convex or bulging, therefore, the lens is, the more nearly it approaches a plane glass, and the more distant or longer is its focus; and the more convex or bulging a lens is, the more obliquely will the rays fall upon its surface, and the more will they be refracted or bent towards its axis.

9. It is on this principle, arising from this property of a convex lens, that burning glasses and optical instruments, such as spectacles, microscopes, telescopes, &c., are constructed. The parallel rays of the sun, which pass through the glass, are refracted to a point, or collected together in the focus, and the heat of that point must be equal to the heat of all the rays which fall on the glass; *or the heat at the focus is to the common heat of the sun, as the area of the glass is to the area of the focus.* Thus if a lens four inches in diameter, *Fig.* 6, collect the sun's rays into a focus at the distance of twelve inches, the image will not be more than one-tenth of an inch in diameter; the surface of this little circle is 1600 times less than the surface of the lens, and, consequently, the heat will be 1600 times greater at the focus than at the lens. Combustible substances placed in the focus of such glasses are instantly consumed; metals are melted, and even vitrified; and other effects are produced beyond the reach of the most active and intense fire. By a large lens, or burning glass, two feet in diameter, made at Leipsic in 1691, pieces of lead and tin were instantly melted; a plate of iron was soon rendered red-hot, and afterwards fused and melted; and burnt brick was converted into yellow glass. Much more wonderful effects were produced by a double convex lens, three feet in diameter, made by Mr. Parker, in England, and which was afterwards presented by the King to the Emperor of China. *Concave mirrors*, placed in a peculiar position to each other and the sun, or to any heated body, produce the same effects as convex lenses. A peculiar combination of a number of plane mirrors can be made to produce the same effects. Archemedes is supposed to have employed some such mirror, in setting fire to the Roman fleet under Marcellus, when bombarding Syracuse.


Fig. 6.

10. The refraction of rays of light following the same laws as that of the rays of heat, *eye-glasses* are constructed upon the same principle as burning-glasses. As the convexity of the cornea of the human eye varies in different individuals and at different periods of life, it varies in its power (in connexion with the other lenses of the eye) of refracting or converging the rays that pass through it upon the *retina*, where the image of any object seen is formed. To remedy these, or other defects in vision, different kinds of glasses are employed. An artificial chrystalline lens is made to supply the place of the natural chrystalline lens of the eye—sometimes removed by surgical operations. In aged persons, the cornea losing something of its convexity, suffers a diminution of its power to converge the rays passing through it upon the retina—so that the point to which the converging rays tend is beyond the retina. The deficient power is supplied by *convex lens*, in a pair of spectacles, which are so selected and adapted to the eye as exactly to compensate for the want of refracting power in the eye itself; and thus the rays are brought to a focus on the retina, where alone a distinct image can be formed. *Near-sighted* persons have their eyes *too convex or round*—forming the image too soon, or before it reaches the retina. *Concave* glasses, dispersing instead of converging the rays of light, counteract this effect, and are therefore used by near sighted persons. Convex glasses are, then, used when the eye is too flat; and concave glasses when it is too round. These glasses are usually numbered, by opticians, according to their degree of convexity or concavity; so that knowing the number that fits the eye, a purchaser can generally be accommodated without the trouble of trying many glasses.

The application of the same property of lenses, and the same laws of refraction in the construction, of microscopes and telescopes, with illustrations, must be deferred until another number.