Optical Department.

The Development of Optics During the Present Century.

A LECTURE DELIVERED BY GEORGE LINDS Y JOHNSON, M.A., M.D., F.R.C.S., AT THE MANSION HOUSE, LONDON, ENG., APRIL 21, 1898.

THE dawn of optics lies in immemorial antiquity. As soon as man began to think he must have been struck by the fact that he was able to see; and light, which he naturally associated with the sun, moon, and stars, must have seemed to him an impenetrable mystery. He noticed the colors of things around him—the flowers, the trees, and the blue sky—the rosy tints accompanying the rising and setting sun, and the many colored rainbow, which he could only associate with divine manifestation. He saw his image in the water, and his staff seemed bent when he thrust it in the stream.

The earliest historical records furnish evidences of some optical knowledge. The long, straight passage in the great pyramid pointing towards the polar star, formed a primitive transit instrument. The Greek philosophers theorized on light, and had the library of Alexandria not been destroyed, we should doubtless know what optics were taught in the Agora and the Museum. The ancients seem to have believed that sight was due to something emitted from the eye which lit up the object. Euclid already was aware that light traveled in straight lines or rays. Lucretius (100 B. C.) propounded the theory of *simulacra*, which seems to have prevailed for a considerable time. According to him every object throws off an impalpable skin or *simulacrum*, having its form and color, whereby we are not only able to see it, but also to dream of it. Lenses are said to be of great antiquity, but they were unknown to the Greeks and Romans, who, at an early date, however, made metal mirrors not only plane, but also convex and concave. Pliny at the commencement of our era mentions mirrors made of glass backed with lead and tin, and Seneca about the same time discusses the similarity of the colors of the rainbow to those seen when sunlight is reflected by water spray or corrugated glass.

During the Middle Ages science was pronounced profane knowledge in all Christian countries, but the Mohammedans devoted themselves assiduously to experimental inquiry, and made surprising discoveries in all branches. Among the brilliant intellects of this Mohammedan golden age, the colossal genius of Al Hazan, who lived in Spain in the 11th century, towers above all. He may fitly be called the father of optics. He found that light existed independently of the eye, discovered refraction, explained the mirage, made a simple microscope, found the relation of conjugate foci, and described the effect of lenses when placed before the eyes.

Two hundred years later spectacles were invented. According to Dr. Plott, the honor falls to our illustrious countryman, Roger Bacon. He was a diligent student of Al Hazan's works and first applied his theories to spectacle making in the year 1280. The invention is usually, however, ascribed to Silvanus Amatus, and the date given is 1285. On his tomb in Florence may be seen the inscription, typical of the times: "Here lies Silvanus Amatus, the inventor of spectacles—May God pardon his sins." Who can say whether these men knew of each other, or whether they worked independently. This great discovery, which has contributed to the happiness and comfort of millions of human beings, attracted considerable attention, and spectacles were made in a number of places; but it took centuries before lenses were applied to any other purpose.

In 1560 a boy, only fifteen years of age, Battista Porta, in Naples, made a tiny hole in a shutter and noticed pictures of objects outside appearing on the wall of the darkened room. He had invented a camera obscura. Later on he placed a convex lens in the shutter, thus improving his camera, and further experiments led him very near to the discovery of the magic lantern. A knowledge of Al Hazan's works enabled him to account correctly for the phenomena he had discovered, and he was struck by the similarity between his camera and the eye.

In the beginning of the 17th century, a Dutch spectacle maker, Hans Lippershey, by fixing a lens at each end of a tube, constructed an instrument which made distant objects look larger and nearer. Galileo heard of this in Venice, then already since three centuries renowned for its glass factories, in which silvered glass mirrors were first made. By means of a piece of an old organ pipe, a convex objective and a concave eyepiece, he contrived to make a telescope which magnified eight times. With this wretched instrument, which could not even be adjusted, he scanned the heavens and made his startling discoveries. Kepler, by replacing the concave by a convex lens, constructed the first astronomical telescope, and obtained greater magnifying power. He also worked out Porta's comparison between the camera and the eye, and obtained a fairly accurate idea of the purpose of the retina and the optic nerve.

In 1621 Snellius, a Dutch mathematician, expounded the law of refraction and his countryman, Drehelius, made the first compound microscope. About the same time a French philosopher, Descartes, discovered that color was an innate property of light, and that by means of a prism the colors of the rainbow could be reproduced.

But it was reserved to Isaac Newton, the greatest master mind of his age, to crystallize into a scientific method that which had been done during the first half of the century. To describe Newton's work in optics and the convincing experiments he made, would lead me far beyond the scope of this lecture. He constructed a reflecting telescope, by substituting a mirror for the receiving lens, thus removing the colored fringes which Kepler had observed in objects seen through his telescope. He took Descartes' prism, determined the behavior of colored rays, and by means of a second prism collected them, so as to form the original beam of white light. Notwithstanding repeated experiments however, he could not get rid of the colored fringes around objects seen through lenses, which led him to the conclusion that this could not be accomplished.

Contemporaneously with Newton, Bartolinus, a Danish physician, discovered the double refraction of light when seen through a crystal of Iceland spar. Newton examined this phenomenon, and called the altered condition of the rays *polarization*. The astronomers Roemer and Bradley, by independent methods, determined the velocity of light, and Huyghens, of The Hague, who greatly advanced the knowledge of refraction, first attributed light to wave vibrations in an all-present medium which he termed *ether*. Newton declined to accept this theory, being convinced that light was due to the emission of a continuous flow of infinitesimal particles of matter.

Newton's ideas prevailed for over a century, and the work he had done, more especially for the advancement of the mathematics of optics, so dazzled the minds of men, that very little progress was made during the 18th century. The only discovery to record is that made independently by Chester Hall, of Essex, and Dolland, of London, who found a method of correcting the colored fringes produced by lenses, with which Newton had battled in vain. They made so-called *achromatic* lenses by combining two lenses of different kinds of glass.

Thus, although at the beginning of the present century achromatic lenses were made, and reflecting telescopes of considerable power were constructed, the microscope was very primitive indeed; spectacles were made with spherical glasses only, and for want of the necessary physiological knowledge, they were fitted in quite an empirical manner; prisms and cameras were used as toys; the large majority of our present optical appliances were unknown; though sextants were used they were wanting in precision, and torch or coal beacons or at best oil lamps with parabolic reflectors protected by a dome of glass, warned the mariner on his approach to land.

Before the 17th century, discoveries were made by a few isolated investigators; gradually communications improved, and the work of the one assisted the other. In the present century the number of workers has steadily increased, and with them the number of scientific societies, each publishing its proceedings. Whenever a new idea is originated it is at once placed at the disposal of the scientific world—the thought of the one engendering thought in thousands of others. Every advance made in one science assists the other, and technology, active in all its branches, is constantly placing new or more perfected material at our disposal.

(*To be continued.*)

A beautiful gold lorgnette chain shows pink coral beads of unusually fine tint at intervals, and the same pink coral is introduced, together with diamonds, on the lorgnette case.

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