THE HISTORY OF SPECTACLES.*

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A SMALL article, and yet how important for mankind and its progress! Without it thousands, or rather millions, of elderly people would no longer be able to enjoy reading, and just as many millions of near-sighted individuals would be deprived throughout their lifetime of the benefit of distinct vision. But we are now so accustomed to the general use of this auxiliary, that we need reminding that for centuries the combined labor of industrial art and of science has been necessary to bring the spectacles, and their scientific selection, to the present state of perfection.

At the very outset the difficult question arises, whether the

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invention of glasses should be credited to the Mongolian or the
Caucasian race. It is possible, that the Chinese used glasses at a
much earlier period than the nations of western Europe. While
those which are in use among them at the present time are similar
to ours, and mostly imported from Europe, there exist some old
pictures which show Chinese reading with glasses of a different
pattern. In one of these they are kept in position by a band, which
passes around the head below the ears and the occiput. In another
they are held by two cords which pass over the ears and hang down
to the breast; they are kept taut by weights attached to their ends.
The lenses are round and very large. These spectacles are also men-
tioned in the narratives of early travelers, and it is stated by them
that the lenses were made out of a slightly yellowish-brown stone,
called “schachi” or teastone, most probably a kind of topaz. In some

collections, a few of such very old Chinese spectacles are still pre-
served. But as more exact data, especially in literature, are wanting,
this question, whether the Chinese made the discovery independently
of and prior to the nations of western Eurasia, remains an open
one, and we will turn our attention to the latter.

Amongst the ruins of old Nineveh an interesting find was made
by Sir Henry Layard,* namely a lens of rock crystal. This oldest
lens in existence is plano-convex, 1½ inch in diameter, with a focus
of 4½ inches. It is fairly well polished. But as to its use, and
whether this one specimen is indicative of a more general employ-
ment of glasses, we are in the dark. Even if the old Assyrians and
Babylonians did possess this art, it became lost afterwards. For to
the ancient Hebrews and Egyptians spectacles were unknown.

* Discoveries Among the Ruins of Nineveh and Babylon, 1853, p. 197.
THE INVESTITURE OF FRIEDRICH OF NUREMBERG WITH THE BRANDENBURG ELECTORATE, APRIL 17, 1417.

From a colored picture of a contemporary manuscript by Ulrich Richenthal, now in the University Library at Prague.
The Greeks were likewise unacquainted with them. In the four treatises on "optics" by Euclid, Heron, Ptolemaeus and Damianus, which have come down to us, not the least mention is made of them. They knew only that by means of the so-called "shoemaker's globe,"
a glass-sphere filled with water, the rays of the sun could be collected and combustible bodies ignited. Aristophanes, in his comedy "The Clouds" alludes to this as a well-known fact.

Among the Romans, the "shoemaker's globe" became a regular part of the instrumentarium of physicians, who used it for cauterizing; later on they also observed that small objects became magnified by it. Winkelmann, in his History of Art (1776), drew the conclusion from the most minute carving of some of their gems that this could not have been executed had the engravers not possessed magnifying glasses. But his further deduction as to the similarity of these to ours is unwarranted.

The main dispute, however, arose over the interpretation of a passage in Pliny, relating to Nero. The original reads as follows: *Nero princeps gladiatorum pugnas spectabat in smaragdo,* ("The emperor Nero viewed the combats of the gladiators in an emerald"). Some scholars construed this to mean that Nero used an emerald as we do glasses, and concluded even that Nero was near-sighted. But this latter opinion, although it has become fixed in the popular mind, is certainly not true, because Pliny, at another place, makes the direct statement that the eyes of Nero were weak for near objects unless he blinked: *Oculi Neronis, nisi cum conniveret, ad prope admota hebetes.* And Suetonius calls them *caesii et hebetes*—dull and weak. Nero was either far-sighted or astigmatic, but not near-sighted.

The sentence just prior to the first quoted passage, that Nero viewed the combats in an emerald, deals with emeralds in general, and states that they, when large enough, and inclined, reflected the images of objects as mirrors do. The logical relation of these two sentences, and the direct statement *in smaragdo,* "in an emerald," leaves hardly any doubt that Nero used the emerald like a small mirror. Had Pliny wanted to say that the emerald was used like our spectacles, *per smaragdum,* "through an emerald," would have been the phrase. Although Lessing, in the 45th of his "Antiquarian Letters," 1768, discussed this subject at length and refuted the mis-interpretation, this has survived not only among the laity but has even found its way into scientific works. As an example of the former I cite the famous dramatized novel by Sienkiewicz, *Quo Vadis*; of the latter, the History of Ophthalmology, by A. Hirsch, 1877.

There being no other reference to glasses in the entire Latin literature, medical as well as non-medical, we may safely state that the use of spectacles was just as unknown to the Romans as to the
From a carbon print of an oil painting on wood by Jan van Eyck at the Academy at Bruges. Between the Virgin and Saint George kneels the donor, Georg van der Pale, holding with the fingers of his right hand a pair of black-bowed glasses.
other ancient nations. Nor is there any mention of them during the first twelve centuries of the Christian era.

At the end of the thirteenth century, however, testimonials to their use begin to appear from different sources and countries. The famous philosopher Roger Bacon speaks of glasses which cause small letters to appear large; this was in 1276, and therefore some authors attributed their invention to him.* In Germany, they are referred to in a collection of minnesänger ballads, in 1280. About 1300, they are fairly well known and used in the Netherlands; Alexander von Humboldt states this especially of Haarlem.

But the credit for the discovery belongs most probably to one of two Italians, who were friends or closely acquainted, Salvino d'Armato degli Armati and Alessandro della Spina.

Armati was of noble family and died in 1317. On his tombstone in Florence there is the inscription, "Here lies Salvino d'Armato degli Armati, of Florence, the inventor of spectacles. May God forgive his sins. He died anno Domini 1317." As the year of the discovery, 1285 is assigned.

*E. G. Caesemaker, Notice historique sur les lunettes et les verres optiques, 1845.
Spina was a Dominican monk of Pisa. In the monastery archives the year of his death is given as 1313, and the following is related of him: "Brother Alessandro della Spina, a modest and good man, learned to make all industrial products of which he saw
or heard. Spectacles, which were made first by some one else, who did not want to communicate anything about them, were then made by him, and were distributed with a cheerful and benevolent heart."

The dictionary of the Academy of Florence (1729) contains under *occhiali* ("spectacles") the following: "Rivalto, a monk of Pisa, in a sermon delivered on February 23, 1305, made the following statement: 'It is not 20 years since the art of making spectacles, one of the most useful arts on earth, was discovered. I, myself, have seen and conversed with the man who made them first.'" Whether he meant Armati or Spita, cannot be decided.

In a manuscript of the year 1289, published first by Dr. Redi in 1648, we find this passage: "I am so debilitated by age that without the glasses known as spectacles, I would no longer be able to read or write. These have lately been invented, much to the benefit of poor old people whose sight has become weak."

All these data are conclusive evidence that the origin of spectacles dates from the end of the thirteenth century, and can be credited to either Armati or Spina, conjointly or independently.

The first physicians to mention them were Gordon, Professor of Medicine in Montpelier, 1305, who stated that, thanks to his excellent remedies, glasses were superfluous; and his contemporary,
Professor Guido, of Avignon, who, after praising his remedies, more modestly remarked that if they did not help, the need of spectacles was indicated.

SPECTACLES.
From a manuscript of the year 1600 at the Germanic Museum of Nuremberg

In the fourteenth century the use of glasses spread slowly but regularly in the different countries of Europe, at first among the
higher classes. References to them, in documents as well as pictures, became more and more numerous; but the masses did not take kindly to the innovation. Wearers of spectacles were not only ridiculed, but the glasses, according to the superstition of the times,
were called a device of the devil. The unsightly frame and the high price were also obstacles to their general employment. Even at the end of the sixteenth century, the price of a pair of spectacles was from 100 to 200 kronen, equal to 40 to 75 dollars.

But as everything of real merit has a tendency to survive, they won their way more and more into favor. At the end of the sixteenth century we find regular guilds of spectaclemakers in Italy, France and Germany, with their own coat-of-arms. In the latter country, the chief city for their manufacture was Ratisbon, and the by-laws of its guild, of the year 1600, are still preserved in the famous museum at Nuremberg. Here are also to be found quite a number of drawings showing the different styles of the frames at that period. In the earliest designs we possess, the lenses are round and contained in a ring of black horn, about one-half inch wide; the two sides are united by a leather band nearly an inch long, and are kept in position by another leather band passing around the head. Soon afterwards we meet with lorgnettes, and in the beginning of the seventeenth century nose glasses made their appearance. Gradually the frame became more light and elegant; the first metal used was iron, followed by the metals now in vogue, such as steel, nickel, gold, etc. In the latter half of the last century
a number of ingenious devices for holding nose-glasses in position have been invented with which you are all well acquainted. The earlier lenses were ground out of a smoky-colored stone, berillus, from which the German name *Parillen*, later *Brillen* is derived. Soon afterwards they were made of glass, the best of which came from Venice. Spectacle-grinders of Venice, for example M.
Lorenzo, of the firm "The Big Spectacles," were famed throughout Europe.

During the fourteenth and fifteenth centuries only convex glasses for reading were known. The concave ones came into use in the beginning of the sixteenth. One of the first to wear them
was Pope Leo X, who was very near-sighted and wore them when hunting. "With them I see better than my companions," are his words. In the Pitti palace, in Florence, hangs his picture, painted by Raphael in 1517, with concave glasses in his hand. The concavity is plainly shown by the reflex.

It had been observed that some weak eyes were not improved by either convex or concave glasses. The reason of this was discovered by the famous scientist Thomas Young to be an unequal curvature of the media, which condition was afterwards termed astigmatism. Young, being astigmatic, studied his own eyes and published his observations in the *Philos. Trans.*, 1801. They created considerable discussion, and later on the astronomer George Airy devised cylindrical glasses for the correction of astigmatism, and had them made for himself by the optician Fuller at Ipswich, 1827. Independently of him, McAllister, of Philadelphia, 1828, and Suscibi of Rome, 1844, also ground cylindrical glasses.

The so-called bifocals, where one frame contains two glasses, the upper for distance and the lower for reading, were invented by Benjamin Franklin. In a letter to Whately of London, 1785, he gives a clear description of them and speaks highly of their convenience. At first these were made just as Franklin made them—and we still occasionally see them—by cutting two lenses of different foci and using one-half of each. Later, the same effect was obtained by cementing an additional oval segment to the lower portion of the distance lens; and the very latest improvement in this direction are the "invisible bifocals," where the former is inserted in a slit in the latter. The optician Theodore Mundorff of New York has succeeded in grinding bifocal lenses (which he calls "Neeranfar") directly out of one piece of glass—a process patented in 1904 and now on the general market.

Periscopic glasses, i.e., those with a concave surface on one side and a convex on the other, and which give a wider field, were recommended as early as 1803 by Wollaston.* But they have come into general use only within the last decades, since the best combination of the two surfaces has been mathematically calculated.

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So far we have dealt with the art of manufacture, and we will now turn our attention to the evolution of the scientific method of selection.

In the beginning and throughout the Middle Ages the selling of glasses, and their adjustment, if we can speak of such, was done

* "On an Improvement in the Form of Spectacle glasses," *Philos. Mag*...
by "spectacle peddlers." Their appearance was striking, and we find them therefore portrayed in quite a number of pictures. This method has survived even to the present day, as you may see daily at different street corners of every large city. Within the seven-

THE SPECTACLE PEDDLER.

From an engraving by W. E. Dietrich in 1741. The woman is testing the power of a glass on the fabric of her apron.

teenth century optical stores were established, first in Germany. Physicians for a long time did not pay much attention to spectacles. They considered it beneath the dignity of their profession to have anything to do with the selection of them, until the middle of the
nineteenth century. Some of them, as for instance Bartisch of Dresden, the most famous oculist of the sixteenth century, even advised against their use.

The earliest numbering of the lenses was crude and arbitrary. The age for which they were considered most suitable was scratched upon the glass, the different makers and sellers having their own
scales. An attempt to establish rules for numbering and selection was made by Daca de Valdes, of Seville, 1623, whose manuscript is the only one that has come down to us out of the first five centuries. As he was unacquainted with either optics or anatomy of the eye, he deals with the subject in an empirical way. Later on, in the beginning of the eighteenth century, and originating in France, the lenses were designated according to their radius of curvature.

The dawn of the seventeenth century marks a new era in optics, by the epochal work of the astronomer Johannes Kepler. The ancient Greeks believed that during the act of vision something ema-

THE BIBLIOMANIAC.
After a woodcut in Sebastian Brant’s *Narrenschiff* (1494).

THE SCHOLAR.
After a woodcut from the *Brösamlein* (1517) attributed to Kayserberg.

nated from the eye towards the object. To discuss the different subsequent theories here would lead us too far. Kepler demonstrated* that the rays of light come from the object, and are refracted by the cornea and lens of the eye to form an inverted picture of the object on the retina. He had a fairly clear conception of near- and far-sightedness and how they were influenced by glasses. Furthermore, he predicated the necessity of accommodation from our ability to see objects far away as well as close to the eye.

During the next two centuries the knowledge of the anatomy and the physiology of the eye made enormous progress in all their de-

*Paralipomena ad Vitellionem, 1604, and *Dioptrice*, 1611.
tails. In spite of this the physicians maintained their reserved attitude, and refused to concern themselves with glasses until the middle of the last century, when a change took place, and the selection of glasses became included in the domain of science.

This was due mainly to the classical works of Donders and Helmholtz, who laid the foundation upon which the superstructure rose by rapid steps.

Donders, of Utrecht* established a strictly mathematical basis, by introducing as the standard the so-called emmetropic eye, an eye in which parallel rays are focussed upon the retina. The two other possibilities, where the rays are focussed in front or behind the retina, are respectively the myopic or near-sighted and the hyperopic or far-sighted eye. These are the three kinds of refraction.

Further Donders distinguished between static and dynamic refraction, the latter being the change of the former by the act of accommodation. Accommodation means the faculty of the eye to adjust itself from distant to near objects and vice versa. The

*On the Anomalies of Accommodation and Refraction of the Eye, 1864.

†In 1644 gold-bearing ore was discovered in Norway from which some ducats were coined, but many were incredulous and claimed that they were made from old coins. Gold was then found in still another place in Norway, and in 1647 King Christian IV had new ducats made bearing on one side, under a pair of glasses, the words Vide mira domini ("Behold the miracles of the Lord"). In the sixteenth century Brunswick had a series of coins which bore on one side a wild man holding a torch in his right hand, and in his left a skull, hour-glass and a pair of spectacles. The letters around are the initials of the rhyme, "Was Hilft Dem Alten Licht Vnd Brill, Der Sich Selbst Nicht Hilft Vnd Kennen Will" ("Torch and glasses will not help the old man who will not help and know himself"). The ducat of the freemasons is very rare and bears below a pair of eyeglasses the legend, Das ganze Geheimnus, "the whole secret."
mechanism of this function had become quite well understood through the progress of anatomy in the previous century and the physiological researches of Helmholtz. During accommodation for near objects the lens becomes more convex, and this is accomplished by a muscle inside of the eyeball. In estimating the static refraction, the accommodation must be excluded or errors will creep in.

While many people are able to relax their accommodation entirely, others, especially children, are unable to do so. When, therefore, chemistry gave us, in atropin and similar alkaloids, remedies by which we are able to paralyze the muscle of accommodation for a short time, it was a welcome aid. By its means all errors from this source can be avoided.

AN OLD WOMAN ASLEEP OVER HER BOOK.
After an etching by Rembrandt (1606-1669.)

The invention of the ophthalmoscope by Helmholtz in 1851 not only enabled the physician to see the interior of the eye, but also to determine the refraction by exact measurement without reference to the information obtained from the person examined. Various modifications of this method have been evolved since, and at the present day, in every thorough test, the patient’s statement is controlled by objective observation.

About thirty years ago a revision of the numbering of lenses took place. In the old system the effect of the lens was the reciprocal value of its radius of curvature, and the calculations had to be
done in fractions. The new, or metric system, takes as its basis the optic value, i.e., the focal distance of the lens. Its standard is a lens with a focus of one meter, the so-called "diopter lens." A lens with a focus of one-half meter, being twice as strong, is called a lens of two dioptries, etc. This new nomenclature which uses whole numbers instead of fractions and makes the calculations considerably easier and quicker, has been universally adopted.

In 1855 Helmholtz devised the ophthalmometer, an instrument by which the curvature of the cornea in the different meridians and thereby its astigmatism can be measured directly; he and his disciple, Knapp of New York, made the first investigations with it. Primarily a cumbersome laboratory instrument, Javal and Schioetz of Paris in the eighties gave it a practical form for daily use, and it is now regularly employed for the determination of corneal astigmatism.

By means of all these instruments and methods of precision the refraction can be accurately calculated; and with the knowledge of the relationship between the power of accommodation and age, the medical advisor is governed by scientific laws in the selection of spectacles.