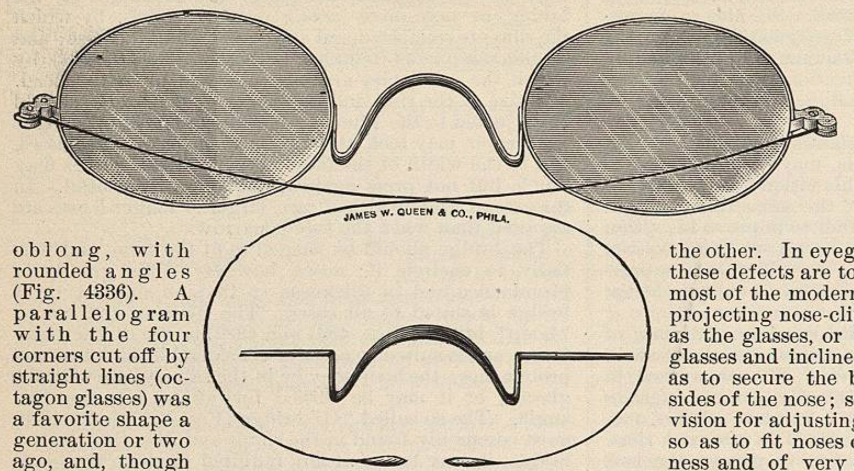

Fig. 4333.

Fashion has played its part in determining the shape of spectacle glasses; the original shape was doubtless circular, but that now generally preferred is a nearly regular oval. Another and, in some respects, preferable form is oblong, with rounded angles (Fig. 4336). A parallelogram with the four corners cut off by straight lines (octagon glasses) was a favorite shape a generation or two ago, and, though rather ungraceful, is still occasionally seen. Pulpit spectacles, so called, have the upper part of the rims flattened, in order to permit the wearer to see over them in looking at distant objects; the glasses are also set, as a rule, obliquely to the direction of the side pieces, but approximately perpendicular to the direction of the visual axes in reading. In ametropia, with defective accommodation, it is often convenient to mount two half-lenses in each rim, the upper half (convex or concave) of a power suited to the correction of the actual hypermetropia or myopia; the lower half, of the power needed for reading;* a similar effect is obtained, though somewhat less perfectly, by grinding the upper and lower halves of the same lens to different radii of curvature. Bifocal spectacles and eyeglasses, generally in rimless mounting, are also made by cementing a segment of a thin convex lens upon the back of the correcting glass required for distant vision, in such position that the wearer looks through it in reading. Still more elegant is a device by which a small and very strong convex lens, made of highly refracting glass, is embedded in the lower half of the glass required for distance; the entire glass is then ground to a uniform surface, so that the reading segment becomes practically in[illegible].† Another useful arrangement consists in mounting a supplementary reading correction in a separate frame, to be hooked upon the front of the spectacles habitually worn in distant vision.

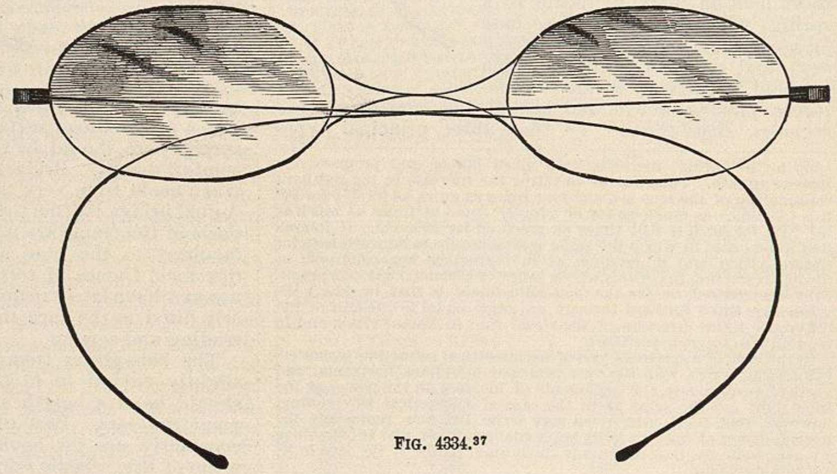

Fig. 4334.[37]

Eyeglasses of the *pince-nez*‡ pattern have been made since an early period in the history of spectacles, but their construction has been greatly improved within the past twenty years. In the older pattern (Fig. 4337) the centres of the glasses often fall much too near together, and the glasses themselves are apt to tip forward in a way that may be detrimental to their effect in distant vision. In many cases, also, they stand so near to the eyes as to allow insufficient room for the play of the eyelashes, and whenever the nose is unsymmetrical one glass is apt to stand noticeably higher or nearer to the eye than the other. In eyeglasses of improved construction these defects are to a great degree obviated. Thus most of the modern eyeglasses have some form of projecting nose-clips, set either in the same plane as the glasses, or in a plane behind that of the glasses and inclined to it at any required angle so as to secure the best possible bearing upon the sides of the nose; some eyeglasses have also a provision for adjusting the clips, upon the two sides, so as to fit noses of almost any shape and thickness and of very considerable degrees of asymmetry. A cork lining to the clips increases their adhesiveness, and so does away with the necessity of strong pressure in order to hold the glasses firmly in position. The tilting of the glasses, in cases of exceptional prominence of the forehead, is obviated by giving a forward slant to the connecting spring. For mounting cylindrical and prismatic glasses the *pince-nez* is generally unsuitable, by reason of the difficulty experienced in holding the glasses in proper position before the two eyes. In many cases of asthenopia, and especially in progressive myopia, the wearing of a *pince-nez* should be prohibited.

A convex lens, preferably of about four inches diameter and a focal length of about eight inches, with a handle by which it may be held at any desired distance from the book and from the eyes, is often used in reading by old persons with failing acuteness of vision. By reason of the greater distance of the glass from the eyes, its magnifying power is much greater than that of convex spectacles, and by varying the distance of the book the recti interni muscles are relieved of more or less of their load in convergence. A combination of two plano-convex lenses, mounted with their convex surfaces nearly but not quite in contact, is to be preferred to a double-convex lens, as giving a flatter field with less distortion of the virtual image.

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* Benjamin Franklin is said to have worn such glasses, and they are commonly called by his name.

† In this construction, and also in the more elaborate arrangement in which the correcting glass for distant vision is built up of two glasses cemented together (*cf.* Fig. 4324, *a–d*), with the small reading lens enclosed in a cavity between them, there is an approach to an achromatic correction in the portion of the glass used in reading.

‡ In a fresco by Dom°. Ghirlandajo (1449–94), in the Church of Sta. Trinita at Florence, an elderly bishop is represented as reading through a *pince-nez* set very low upon the nose; the rims of the glasses are circular, and the connecting arc is apparently rigid. This construction and manner of wearing the *pince-nez* recalls an objection formerly made to it, as compressing the nostrils and imparting a nasal quality to the voice. A fac-simile of the portion of the fresco containing this head has been reproduced, in color, in one of the publications of the Arundel Society, London, 1860.

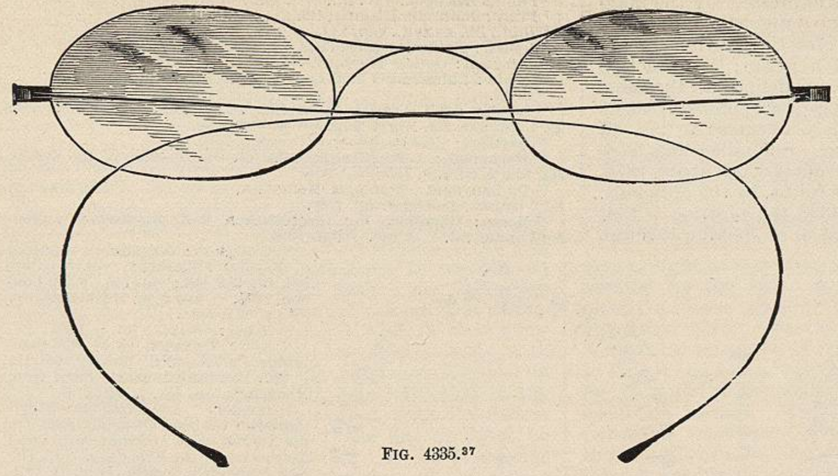

Fig. 4335.[37]

The different methods used in testing eyes for the correction of the several refractive and accommodative defects, whether simple or complicated, have been described in this Handbook under the titles *Astigmatism*, *Hypermetropia*, *Myopia*, *Presbyopia*, *Ophthalmometer*, *Ophthalmoscope*, *Optometry*, and *Shadow-Test*. The points to be particularly investigated are (1) the acuteness of vision, (2) the state of the refraction, (3) the state of the accommodation, and (4) the relation of the accommodation to the convergence. Only after these determinations have been made, with a close approximation to accuracy, can the selection of glasses for any particular kind of work be intelligently made. In the present state of diffusion of knowledge these tests can be safely intrusted only to the ophthalmic specialist — physicians and spectacle dealers being alike incompetent, as a rule, to decide any but the simplest questions. A person who has arrived at the age of forty-five years without having experienced any trouble in the continuous use of his eyes, may fall into no very grave error in buying weak convex glasses when he becomes conscious that he is beginning to suffer from the disabilities of presbyopia; but even in such a case an examination of the eyes by a competent observer may bring to light some measure of astigmatism which it may be well worth while to correct, or possibly some pathological condition which it may be of vital importance to detect in its incipiency. The indiscriminate selling of concave spectacles and eyeglasses to young myopes, or to young persons hastily assumed to be myopic, is a most reprehensible, as it is, unfortunately, an almost universal practice.

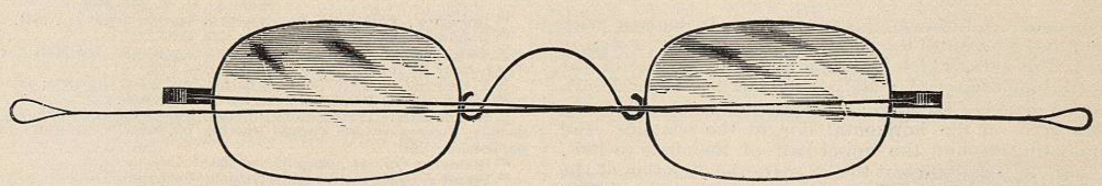

Fig. 4336.[37]

The power of convex and concave spectacle lenses is expressed by numbers, with the plus (+) or the minus (−) sign prefixed. Two systems of numbering are in use, the older (inch) system, based on a unit-lens with two curved surfaces of equal radii of one Paris inch, and the newer (metric) system, in which a lens of a focal length of 1 metre (dioptrie—D) is taken as the unit. In the older system it happens, through an accidental relation of the Paris to the English inch, that the focal length, in English inches, of a biconvex or biconcave lens is almost exactly the same as the radius of curvature of the two surfaces in Paris inches. The two systems may, therefore, be regarded as based upon unit lenses of one English inch and 1. metre focal length, respectively. The practical difference, in using the two systems, consists in the fact that in the case of the smaller unit, of 1. dioptrie, the power of any lens of a power greater than this unit is expressed by a whole number or by a whole number and a decimal fraction, whereas in the case of the larger unit, of one English inch focal length, the power of any spectacle lens is expressed in the form of a vulgar fraction, with unity for its numerator, and the focal length of the lens, in English inches, for its denominator. The notation according to either system may, within a very small and practically negligible margin of error, be transformed into that of the other by taking the metre lens (dioptrie) as equivalent to the lens numbered $\frac{1}{40}$ in the inch system.

Cylindrical lenses are numbered either according to their power (in dioptries) or their focal length (in English inches) in the meridian at right angles to the axis.

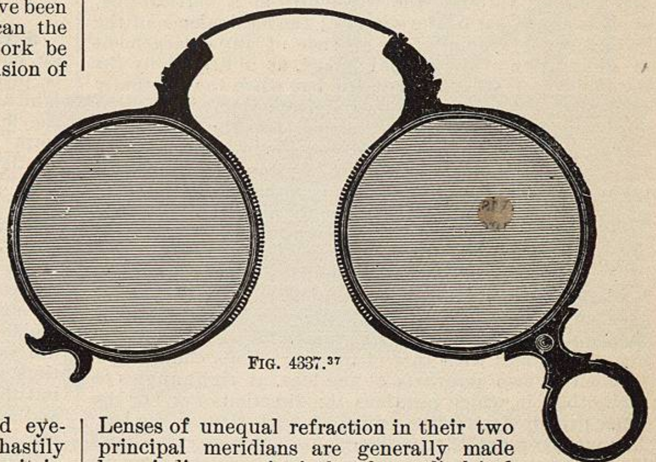

Fig. 4337.[37]

Lenses of unequal refraction in their two principal meridians are generally made by grinding a spherical and a cylindrical surface upon the two sides of the same glass, and the formula for such a lens is written, for each surface, as if the lens were made up of a plano-spherical and a plano-cylindrical lens with their plane surfaces in contact. The direction of the axis of a cylindrical lens or surface is defined by noting its inclination (in degrees of arc) to either the vertical or the horizontal meridian of the eye. If the two surfaces of any lens, at the points in which they are cut by the visual line, are not parallel, the deviation from parallelism is expressed by the magnitude of the angle which the two tangent planes make to each other, as if the two refracting surfaces were ground upon the two surfaces of a prism; the direction of the refracting angle of a prism is defined in the same manner as the direction of the axis of a cylindrical lens.

In prescribing spectacles it is convenient to lay off these angles on a printed diagram. Such diagrams have been in common use in this country since about 1876, and are furnished, in a variety of forms, by the opticians. In the diagram shown in Fig. 4338 the position is that in which the wearer is supposed to be looking through his glasses, and the angles are marked, in degrees, with the plus (+) sign to the right, and the minus (—) sign to the left of zero, which is taken at the upper end of the vertical meridian. A widely used, but less natural, system of marking the angle of inclination is by beginning with zero on the horizontal line, at the left side, and numbering around the upper half of the circle to 180°. A half-circle is sufficient to designate the direction of the axis of any cylindrical lens, but the whole circle of 360° is needed to indicate the different directions in which it may be required to turn the refracting edge of a prismatic glass.

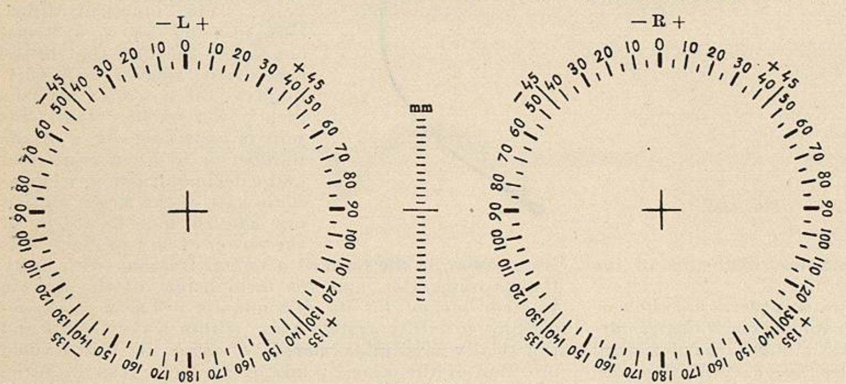

FIG. 4338.

The power of any (convex or concave) lens is measured by finding the equivalent (concave or convex) lens, and looking through the two lenses at a vertical line, such as a sash-bar of the window; the equivalence of the two lenses is shown by the absence of any enlargement or diminution of the virtual image, as indicated by the immobility of the image of the bar when the mutually neutralizing glasses are moved from side to side. In applying this test to a cylindrical lens the axis of the lens must be turned so as to coincide in direction with the line used as a test object; in the case of a sphericocylindrical lens the refraction is measured in the two principal meridians in succession, the algebraic difference of the two measurements representing the cylindrical refraction. The direction of the two principal meridians of a cylindrical or spherico-cylindrical lens is found by holding the lens in a plane perpendicular to the visual axis, and looking through it at the sash-bar; the lens is then rotated, in its own plane, until the direction of the image coincides with that of the bar. This condition is fulfilled in two positions of the lens, at right angles to each other, in which positions the direction of one or the other principal meridian coincides with that of the bar. The middle point of any spherical or spherico-cylindrical lens is found by noting the point at which the crossing of two sash-bars coincides in the image and in the object.

John Green.

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SPECTROSCOPY, MEDICAL.—The spectroscope is an instrument for examining the *spectrum*. A *spectrum* is, primarily, the series of colors produced when a ray of white light is transmitted through any transparent body, the surfaces of which are not parallel. The general form which this transparent body takes is that of an equilateral *prism* of glass, the sides forming an angle of sixty degrees. Hollow prisms with sides at the same angle are also used, being filled with transparent liquids.

Sir Isaac Newton first made the observation that when a ray of white light is transmitted through a prism the ray is not only bent out of its course, but is spread into an array of colors, the order of which is nearly invariable, no matter what the source of light or the material of which the prism is composed. Since the facility of differentiating colors varies in different persons, the exact tints of the spectrum so formed are not easy to express, but they are generally assumed to be seven in number, and arranged as follows: violet, indigo, blue, green, yellow, orange, red. If the ray of light be, as in Newton's original experiment, admitted through an opening of appreciable dimensions, the colors will be somewhat confused and will appear unbroken, but when the opening is very narrow a more distinct effect is produced, and, as will be seen below, the spectrum is crossed by numerous dark lines. It is a law of the propagation of light that when a ray passes from one transparent substance to another of different density it undergoes a deflection, known technically as *refraction*. The direction and extent of this refraction depend on the nature of the materials and on the difference of the densities. When the ray passes from a rarer to a denser subtance—for instance, from air to water, or from water to glass—the ray is bent (refracted) so as to be more nearly parallel to a line perpendicular to the surface of contact, while if the ray passes in the reverse direction—that is, from a denser to a rarer body, as from glass to water—the refraction is away from the perpendicular. It is upon this principle that the image-forming and magnifying properties of all lenses depend.

The accepted theories in regard to light refer it to very rapid vibration, and the difference between the various colors is supposed to be due to differences in the rate of vibration. White light is supposed to contain all the rates of vibration, and when such a ray undergoes refraction the different vibrations are refracted to different degrees, and hence are separated. If we view a ray through a plate of glass or other transparent body with parallel sides, the refraction produced in one direction on entering the glass is corrected by the refraction in the opposite direction on emerging, so that, with the exception of a slight displacement of the line of light, no striking optical change is manifest. If, however, the equilateral prism is used, the refraction on emergence is in the same direction as on entering, and the optical action is exaggerated. The separation of the different vibrations that compose a ray of white light is called *dispersion*, and is not coextensive with refraction; that is, bodies of equal refractive power do not necessarily separate the colors to the same extent. This law is a very important one in practical optics, for all lenses are forms with more or less prismatic outlines, and hence produce a dispersive effect. If it were only possible to prevent production of color by neutralizing the refraction, it would be impossible to construct any convenient optical apparatus free from colored images, but by combining different varieties of glass in such forms as to have equal and opposite dispersive powers with difference of refraction, large lenses entirely free from color defects (achromatic) may be constructed.

In the spectroscope the object is to secure as complete and extended a dispersion as possible; that is, to separate the colors thoroughly. For these purposes prisms of dense glass, or hollow prisms filled with carbon disulphide, CS_2, are used.

The simplest method of examining the spectrum is to allow a ray of light to enter a dark room or dark box through a small opening and fall upon a prism. Upon the side of the room opposite the opening will be seen a more or less confused spectrum, in which all the colors will be found diverted from the path which the original ray would pursue if it did not enter the prism, the violet being most diverted and the red the least. Such a method of observation, however, is unsuitable for scientific purposes. The most serious defect in it is that if the ray has an appreciable thickness the vibrations on one part interfere and overlap those of the other, so that the series of colors obtained is really a combination of a number of spectra not coincident with each other. To obtain a pure spectrum the ray must be reduced to an exceedingly fine line of light, in which there will be but few sets of vibrations. This is accomplished by using a very narrow slit, and shutting off all light from the prism except that which passes through this slit. The observation is also much facilitated by viewing the spectrum through a telescope of low magnifying power.

About a century ago Dr. Wollaston, an English chemist, discovered, by using such a slit, that the spectrum of sunlight is not continuous, but is interrupted by numerous fine, dark lines. He did not develop this observation, and it was not until 1814 that Fraunhofer, a German optician, rediscovered these lines and mapped the positions of some of them. A few of the most prominent he distinguished by letters of the alphabet. They have in consequence generally been known as the Fraunhofer lines. They are all at right angles to the direction of the spectrum, and their distance from each other depends on the dispersive power of the prism. Since each particular line is always seen in the same color, and is more easy to define than the limits of the color itself, the lines are preferred for purposes of comparison.

Various improvements and advances in the construction of apparatus for observing spectra have been made from time to time, until the spectroscope in its usual form consists essentially as follows: A straight tube terminates at one end by a narrow, upright, adjustable slit, and at the other a convex lens, the focal length of which is the distance between it and the slit, so that the rays of light as they pass through the latter are rendered parallel by the lens. In the course of these rays is placed a dense glass prism, or series of prisms, greater dispersion being attained by a combination of prisms. A movable telescope of low magnifying power, arranged so that it can be brought in the course of the rays emerging from the prism, enables one to view conveniently the spectrum formed. Such an arrangement constitutes a *refraction spectroscope*. In the cut (Fig. 4339) there is shown a third tube, illuminated by a candle. This contains a graduated scale, an image of which is projected in the field of view above the spectrum, for the purpose of measurement, as given below.

Another form of the instrument depends on a somewhat different principle, and, as it is now in frequent use and possesses advantages over the older form, it will be necessary to describe it.

When the surface of a polished plate ruled with fine lines in close proximity is viewed obliquely, series of spectra are seen which are due to interferences in the different light waves as they are reflected from the angular surfaces produced by the ruling. This effect is called *diffraction*, and a plate so arranged is called a *diffraction grating*. The superiority of such an instrument rests principally on the fact that in all parts of the spectra the colors are proportionately distributed. In the ordinary spectrum, as seen by the prism, the dispersion is proportionately greater toward the violet end, and consequently this portion is abnormally spread out and the distances between the dark lines are exaggerated.

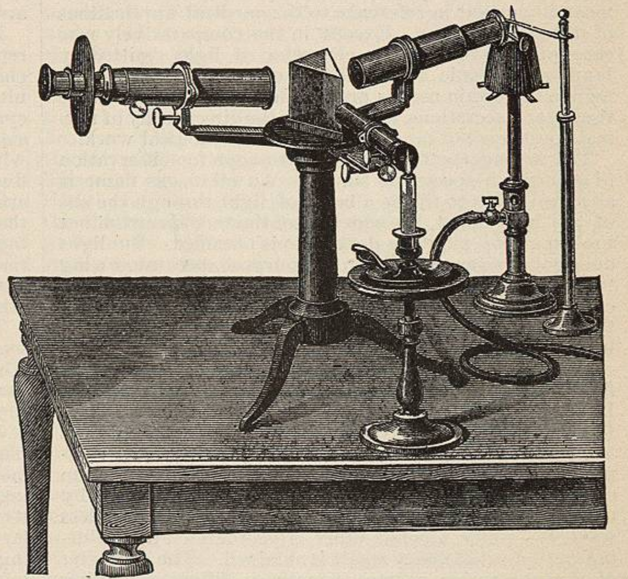

FIG. 4339.—Ordinary table spectroscope. In use the prism and abutting ends of the tube must be well covered to exclude light. This is usually attained by inserting them in the circumference of a brass box.