Spring, furnishes a water which is still richer in solid constituents. The analysis shows that one United States gallon contains (solids): Sodium sulphate, gr. 23.26; potassium sulphate, gr. 5.63; calcium sulphate, gr. 36.11; calcium chloride, gr. 5.59; magnesium chloride, gr. 4.11; magnesium carbonate, gr. 3.51; organic and volatile matter, gr. 12.11; and very small quantities of ammonium chloride, magnesium nitrate, magnesium phosphate, iron sesquioxide, alumina, and silica. Total, 92.71 grains.

The analysis of the water of the third spring, known as the Lakatah Spring, shows that one United States gallon contains (solids): Sodium sulphate, gr. 8.82; potassium sulphate, gr. 3.33; calcium sulphate, gr. 16.29; calcium chloride, gr. 8.50; magnesium chloride, gr. 3.14; magnesium carbonate, gr. 3.04; organic and volatile matter, gr. 8.05; and very small quantities of ammonium chloride, calcium phosphate, magnesium nitrate, iron sesquioxide, alumina, and silica. Total, 53.79 grains.

According to the report of the National Association of Railway Surgeons, which visited this resort in 1893, "treatment by the Hot Springs water may be said to stimulate all the secretions and organic functions, to promote digestion and assimilation, and to favor tissue metamorphosis and excretion, thereby relieving internal congestions, stimulating blood-making, increasing the appetite, and favoring new and healthy tissue at the expense of the old and inactive." This treatment may therefore be confidently recommended in "gout and rheumatism after the inflammatory stage; in neuralgia, especially when depending upon gout; in metallic or malarial poisoning; in paralysis not of organic origin; in neurasthenia; in the early stages (only) of Bright's disease; in syphilis; in functional diseases of the liver; in dyspepsia, not of organic origin; in catarrhal affections of the respiratory tract; . . . and in chronic skin diseases, especially of the squamous variety."

James K. Crook.

SOZOIODOL.—(Di-iodo-para-phenol-sulphonic acid.) An acid base which was introduced in 1887 as an antiseptic. It contains forty-two per cent. of iodine, twenty per cent. of carbolic acid, and seven per cent. of sulphur. The acid itself is not employed, but it forms salts which possess all the properties of the acid. The potassium and sodium salts are the ones most employed. They resemble one another in physical characters, forming in colorless, well-defined prisms, soluble in water, the potassium compound in fifty parts and the sodium in fourteen.

The use of these compounds is in all those conditions in which iodoform is likely to be proved useful. It is said to be preferable, as it is soluble in water and glycerin, does not decompose when exposed, readily combines with other substances, and is free from irritating action and disagreeable odor. The zinc salt has been specially recommended for gonorrhœal discharges. It is soluble, one part in twenty of water. All the solutions should be freshly prepared and not exposed to the light, as they are decomposed and free iodine is liberated.

The mercurial salt is a lemon-yellow powder, soluble in about five hundred parts of water. It is mainly employed in the treatment of syphilitic affections. It has been recommended as the most suitable form of mercury for hypodermic injections. The injections should be made in the gluteal regions, alternately on the right and on the left side. It causes a little pain, but the local effects are said to be much less than with any other mercurial salt. The dose is one grain and a half, and one injection a week is equal to three of other forms of mercury. The absorption of the drug is rapid, and the gums have to be carefully watched, as its action is very marked.

Beaumont Small.

SOZOL.—(*Paraphenol-sulphonate of aluminum.*) It occurs in brownish granules of a strong astringent taste and faint carbolic odor. It is very soluble in water, glycerin, and alcohol, and forms very stable solutions.

It is not a powerful antiseptic or bactericide, but has been found to be a very serviceable application to wounds, ulcers, etc., as it possesses an astringent action in addition to its antiseptic properties.

Beaumont Small.

SPARKLING CATAWBA SPRINGS.—Catawba County, North Carolina.

Post-Office.—Sparkling Catawba Springs. Hotel and cottages.

Access.—Viâ Western North Carolina Railroad to Hickory, sixty miles west of Saulsbury; thence six miles by carriage to springs.

The location of the Sparkling Catawba Springs is within the shadow of the Blue Ridge Mountains, 1,150 feet above the sea level. This part of the State, known as the "Piedmont Section," has long been famous for its bracing climate, pure air, and uniform temperature. The springs are three in number, and gush from the ground in a shaded valley surrounded by a circular range of timbered hills and within one mile of the banks of the Catawba River. No analysis has been made, but the springs are said to be blue and white sulphur and chalybeate in character. The new hotel and cottages afford comfortable accommodations for about four hundred guests. We are informed by Dr. E. O. Elliott, of the springs, that the waters possess well-marked alterative and tonic properties, and generally increase the appetite, assist the digestion, and promote the assimilation of food. A very complete and comfortable bathing establishment is at hand. *James K. Crook.*

SPARTA MINERAL WELLS.—Monroe County, Wisconsin.

Post-Office.—Sparta. Hotel.

Access.—Sparta is a station on the Chicago, Milwaukee, and St. Paul Railroad, two hundred and fifty-five miles from Chicago. Bulletin 32 of the United States Geological Survey reports twelve mineral wells in Sparta, only two of which appear to have been analyzed. We present the following analysis of the Magnetic Well, made by J. M. Hirsh in 1876: One United States gallon contains (solids): Magnesium carbonate, gr. 3.35; iron carbonate, gr. 11.94; and very small quantities of manganese carbonate, calcium carbonate, ammonium carbonate, lithium carbonate, strontium carbonate, barium carbonate, potassium sulphate, sodium sulphate, calcium sulphate, sodium chloride, calcium chloride, sodium phosphate, aluminum phosphate, sodium iodide, and silica. Total, 19.25 grains. This analysis shows an almost pure chalybeate water, the remaining ingredients being all of a secondary character.

James K. Crook.

SPASMS. See *Convulsions.*

SPEARMINT.—*Mentha Viridis. Brown, Garden, Lamb,* or *Mackerel Mint.* "The dried leaves and tops of *Mentha spicata* L. (fam. *Labiatæ*)," U. S. P.

Spearmint is a native of Europe and Asia, and has spread widely through nearly all temperate regions, where it is also cultivated to a large extent, and shows a high degree of variation in characters. It usually covers quite large patches, propagating by slender runners. The quadrangular, slender, frequently purplish stems are prostrate below, one to two or three feet long, and much branched. The drug is thus described:

Sparingly and obscurely hairy, the hairs short and stout, without menthol crystals in their cells; branches quadrangular, slender, usually pale green, rarely purplish; leaves opposite, exstipulate, very shortly petioled, the blades usually less than 5 cm. (2 in.) long and about one-third as broad, lanceolate, or lance-ovate, rounded at the base, acuminate and acute, sharply serrate, thickish, and rigid, deep and usually dark green; flower spikes usually appearing clustered at the summit, interrupted, elongated, and acute, about 5–8 mm. (⅕–⅓ in.) thick; flowers about 3 mm. (⅛ in.) long, the calyx tube nearly

equally five-toothed, ten-nerved, the corolla light purple, nearly equally four-lobed, the stamens four, nearly equal, rather long; odor characteristic, aromatic, rather heavy; taste characteristic, pungent.

It is readily distinguished from peppermint by the elongated, slender, and acute flower spikes, the relatively longer stamens and style, and the ranker odor. As seen under the microscope, its hairs never exhibit menthol crystals.

The only important constituent of spearmint is about one per cent. of volatile oil, with which there is associated a little tannin. This oil, although quite similar in properties, is very distinct in composition from the closely related peppermint oil. It contains no menthol, nor apparently any other crystalline substance. Its important constituent appears to be carvone (see *Caraway*). Pinene and limonene also exist.

The action and uses of spearmint are almost identical with those of peppermint. It is somewhat milder in action, on account of which it is often preferred for administration to infants.

Powdered spearmint is often given in doses of 1–2 gm. (gr. xv.–xxx.). The infusion is also popular. The best form of administration is the oil (*Oleum Menthæ Viridis*), dose one to five minims, or one of its two preparations.

The spirit or essence (*Spiritus Menthæ Viridis*) contains ten per cent. of the oil and one per cent. of spearmint, and the dose is 0.3–1 c.c. (♏v.–xv.). The water (*Aqua Menthæ Viridis*) has a strength of 0.2 per cent. and the dose is 15–60 c.c. (fl. ℥ ss.–ij.). *Henry H. Rusby.*

SPECTACLES—from *spectare,* to view; French, *besicles,*[*] *lunettes;* German, *Brille;*[*] Dutch, *bril;*[†] Italian, *occhiali;* mediæval Latin, *perspecillum, conspecillum, ocularius*—are first mentioned about the close of the thirteenth century.[‡] Seneca mentions the fact that "letters, however minute and indistinct, appear larger and clearer when viewed through a glass globe filled with water."[9]

The first mention of a lens, properly so called, is attributed to the Arabian mathematician Alhazen (*obt.* 1038),[10] who describes the magnifying property of a segment of a sphere of glass.[11] Roger Bacon (*circa* 1267) mentions the magnifying property of convex lenses, and suggests the benefit to be derived from their use by old persons with weak sight.[12] The step from the use of a convex lens, as a magnifier, to the construction of binocular eyeglasses or spectacles, to be worn by presbyopes in reading, implies a considerable development of the optician's art, in the direction of grinding lenses of relatively long focus. The invention of spectacles is variously attributed to Salvino degli Armati, a Florentine (*obt.* 1317),[13] and to Allessandro della Spina, a Dominican friar of Pisa (*obt.* 1313). The use of concave glasses, as a help to myopes in distant vision, must have followed at no very long interval; the date of their first employment is, however, unknown. The necessity for the selection of lenses of different focal length for different persons, as well as for the same person at different periods of life, must also have been very early recognized; but there is no reason for believing that the choice was made in any better way than by trying them at random, until a pair was found which appeared to be suited to the kind of work for which they were to be used.[*] Certain it is that spectacles had been in use for from two to three centuries before the theory of their action was explained,[†] and it is only since the middle of the nineteenth century that anything like a complete understanding of the subject has been reached.

Spectacle lenses, as late as the second half of the eighteenth century, were generally, so far as is known, of the plano- or double-convex, or of the plano- or double-concave form.[16] Both the plano-convex and the plano-concave glasses appear to have been mounted, sometimes with the plane surface and sometimes with the curved surface next the eye. Concavo-convex lenses were used to some extent in the eighteenth century, but with varying practice as regards the side turned next the eye.[‡][17] Under the name of *periscopic* spectacles, concavo-convex lenses, with the concave surface turned toward the eye, were brought into use by Wollaston (1804).[18] A special construction of double-convex and double-concave spectacle lenses, made by grinding the two surfaces of the glass to cylindrical curves of equal radii, but with crossed axes, was introduced (before 1830) by Galland de Cherveux;[19] such lenses are still manufactured in limited quantity, but, aside from certain inherent defects, they offer no compensating advantage over the several forms of lenses with spherical surfaces; their existence in commerce made it possible, however, to furnish a cylindrical surface, on demand, at a time when plano-cylindrical lenses were not yet readily obtainable. Cylindrical lenses proper, as used for the correction of astigmatism, were first employed by G. Airy, Astronomer Royal (1827),[20] who was himself the subject of compound myopic astigmatism. Airy discussed the relative advantages, in compound astigmatism, of a bicylindrical lens of unequal radii of curvature, and a spherico-cylindrical lens. The common use of cylindrical spectacle lenses dates from the special study of astigmatism by Donders.[21] Since 1884 it has been possible to have spec-

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[*] From the old French form *bericle,* diminutive of *berille;* Latin, *berillus, beryllus;* βήρυλλος, the beryl[1]; *cf.* the derivation of "brilliant"—French, *briller,* etc.—from *berrylus.*[2]

[†] From *berillus, beryllus,* βήρυλλος, the beryl; "the colors of the beryl range from blue through soft sea-green [aquamarine] to a pale, honey yellow, and in some cases the stones are entirely colorless";[3] *ocularii vitri aut berillorum:* Guy de Chauliac (1363).[4] The most available material for spectacle lenses, excepting glass, is rock crystal or quartz, and it is highly probable that this mineral, still largely used under the name of pebble, was utilized by the older opticians.

[‡] Spectacles, both convex and concave, were in common use by the Chinese before the opening of commerce with Europe. They were made of a transparent stone, of a color like that of a strong infusion of tea, called *scha-chi* (tea-stone), and were tied upon the head by silken cords.[5] Chinese spectacles are now made of rock crystal, and are mounted in thick frames of tortoise shell or of metal, evidently borrowed from old European models.

The common use of some form of magnifying glass by the ancients is wellnigh proved by their perfect workmanship as displayed in the engraving of gems. On the other hand, it appears certain, from the notices on presbyopia and myopia, by Paulus Ægineta (seventh century A.D.),[6] and by later as well as earlier writers, that they had not applied lenses to the relief of persons laboring under these disabilities.

Pliny's description of the visual defect of the Emperor Nero[7] strongly suggests a case of myopia or of compound myopic astigmatism. The statement of Pliny—Nero princeps gladiatorum pugnas spectabat in zmaragdo[8] — taken in connection with what is said of this gem in the same chapter, would seem to be best explained upon the supposition that the emperor possessed a large and highly polished emerald, or gem of like color, most probably of unequal curvature in its two principal diameters, and that he viewed the combatants, in the strong light of the amphitheatre, by reflection from its convex surface. This theory would imply that the use of the gem for this purpose was the result of an observation made by Nero himself, who may, therefore, be accredited with the discovery of an optical device suited to the correction of myopia, or of compound myopic astigmatism; the invention would appear to have died with the inventor.

[*] Bartisch (1583) protests earnestly against the widely spread abuse of spectacles.[14]

[†] "Maurolicus, in his treatise '*de lumine et umbra*' (1554), considers the crystalline as the principal instrument of vision, and as transmitting to the optic nerve the images of objects; and he explains why some persons are long-sighted and others short-sighted, according to the less or greater convexity of the surfaces of the crystalline, showing that in the former case the rays have not been converged to a focus when they reach the retina, while in the latter they have been converged before they reach it. He explains, also, how the convergency may be hastened in the long-sighted eye by the use of a convex glass, and delayed in the short-sighted by a concave one. These observations of Maurolicus were not known to Kepler, when it was proposed to him, as a question by his patron, Dietrichstein, in what manner spectacles assisted sight? The first answer he gave, as he tells us in his '*Paralipomena ad Vitellionem*' (1604), was, that convex glasses were of use by making objects appear larger. But his patron observed, that if objects were by them rendered more distinct, because larger, no person would be benefited by concave glasses, since these diminished objects. . . . He now gave a clear account of the effect of lenses, whether within or without the eye, in making the rays of a pencil of light converge or diverge; and explained that convex glasses assist the sight of presbyopic persons by so altering the direction of rays diverging from a near object, that they fall upon the eye as if they had proceeded from a more remote one, that concave glasses benefit the myopic by producing a contrary effect upon rays which diverge from a distant object, making them fall upon the eye as if they proceeded from a near one."[15]

[‡] Aside from the misinterpretation of special optical formulæ, caprice has played its part in determining many eccentricities of practice; from the beginning, the business of selling spectacles appears to have been conducted largely under the cloak of mystery, and very often of deliberate misrepresentation.

tacle lenses ground to order with a convex or concave surface of unequal radius of curvature in its several meridians, thus producing, by means of a single curved surface, the effect usually obtained by the combination of a cylindrical with a spherical surface.[22] The curved surface of such a convex lens represents a small area cut out from a large surface of revolution corresponding to the rounded rim of a wheel; the concave surfaces produced by this method are such as may be worked upon a grinding tool having the form of such a wheel.* Prismatic glasses, suggested to Donders by his colleague, Krecke, as a possible means of re-establishing binocular vision when it has been lost through the deviation of the visual axes in strabismus, were made the subject of special study by Donders,[24] and have since held a place among the recognized means of dealing with certain conditions referable to disorders of the external muscular apparatus of the eye. The decentration of ordinary convex or concave lenses, in order to give to the combination of the two spectacle glasses some measure of prismatic effect, was also discussed by Donders.[25] Decentrated convex lenses had already been used in the dissecting spectacles of Brücke,[26] and in the refracting stereoscope of Brewster.[27] Stenopæic spectacles—from στενός, narrow, and ὀπή, a peep-hole—were also employed by Donders,[28] chiefly for the purpose of admitting to the eye such rays only as correspond to a selected limited area of the cornea or crystalline. Like the so-called *panoptic* spectacles of Serre d'Uzès,[29] they are essentially the same thing as the obsolete strabismus goggles (*Schielbrillen—louchettes*). The snow-goggles of the Esquimaux, which cover the entire front of the eyeball, with the exception of a narrow horizontal slit, may be classed with stenopæic spectacles, although designed primarily as protectives against the injurious effects of strong sunlight reflected from the snow.

In very high grades of myopia, and especially in cases of irregular myopic refraction of high degree, the best attainable visual result may often be had by looking through a small circular hole or a slit in a thin opaque card or disc of blackened metal.

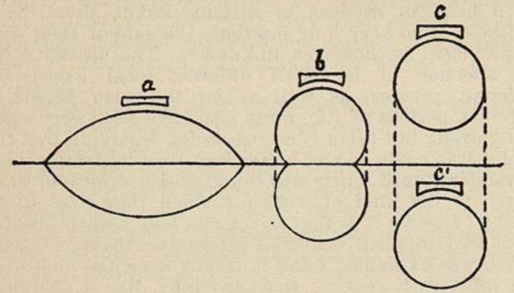

FIG. 4321.

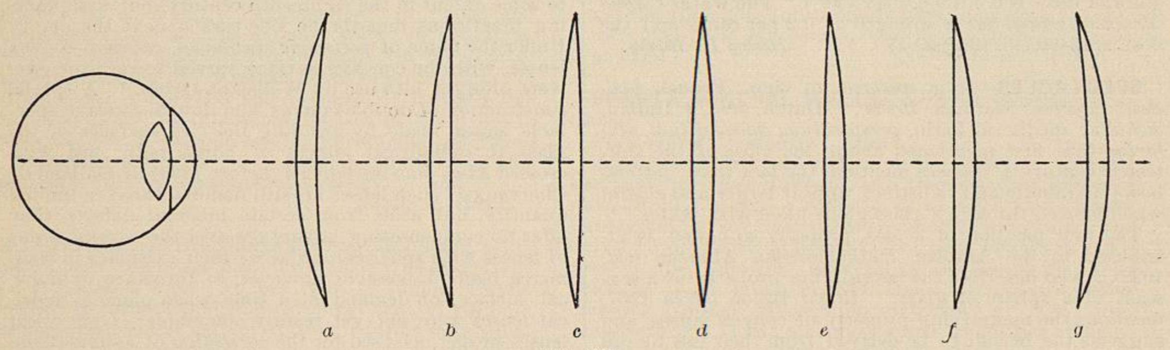

FIG. 4322.

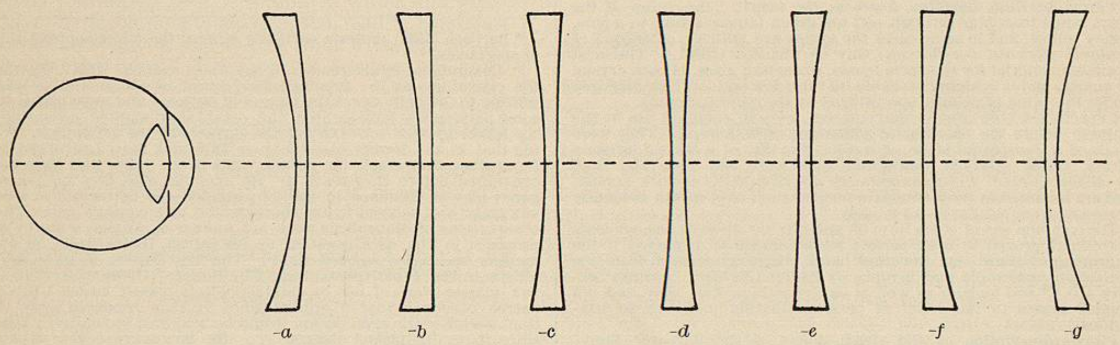

FIG. 4323.

The several forms of spectacle lenses, as they have been or may be mounted before the eye, are shown, for convex and concave lenses respectively, in Figs. 4322 and 4323. Of the convex lenses (of positive focus), *a* and *g* (Fig. 4322) are menisci; *b* and *f* are plano-convex; *c* and *e* are double convex, with surfaces of unequal radii of curvature; and *d* is double convex, with surfaces of equal radii. In concave lenses (Fig. 4323) we recognize the corresponding forms: *–a* and *–g*, concavo-convex; *–b* and *–f*, plano-concave; *–c* and *–e*, double concave, with surfaces of unequal radii of curvature; and *–d*, double concave, with surfaces of equal radii. Of these, *g* (positive meniscus, with the concave surface turned toward the eye), and *–a* (negative concavo-convex, with the concave surface toward the eye), are especially designated as periscopic (from περί and σκοπέω) glasses; they offer a certain advantage when the eyes are turned so as to look obliquely and eccentrically through them, the advantage being greater according as the concave surface, as in *–a*, is of shorter radius of curvature.[30] These several forms of lenses, other than the plano-spherical, may be resolved into combinations of two lenses, each with a spherical and a plane surface, placed with their plane surfaces in contact (Fig. 4324, *a*, *b*, *c*, *d*). Inasmuch as a smaller effective area than that bounded by the usual setting is quite sufficient for many of the uses for which spectacles are worn, it is often possible notably to reduce the weight of the glasses, when required to be of very short focus, by the adoption of forms like those shown in Fig. 4324, *e*, *f*, made by cementing a small plano-convex upon a larger plano-convex or plano-concave lens, or *g*, *h*, in which a deep concave surface is ground in a lens of any required configuration.

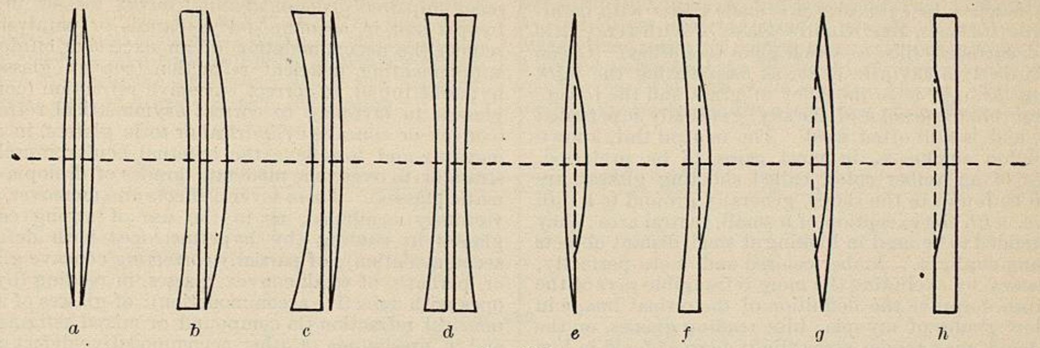

FIG. 4324.

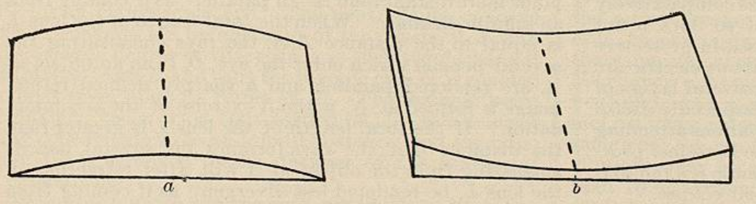

FIG. 4325.

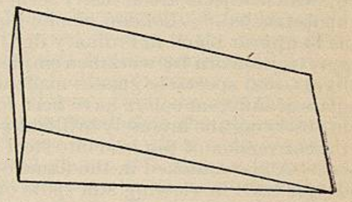

FIG. 4326.

Cylindrical lenses are found in trade of two forms, namely, plano-convex and plano-concave (Fig. 4325, *a* and *b*); the dotted line represents an element of the cylindrical surface, which is parallel to the axis of the cylinder of which the lens-surface is a segment; they are manufactured by machinery, in different thicknesses, so that any required spherical surface, convex or concave, may be ground to order upon the plane side. The power of a plano-cylindrical lens varies, in its several meridians, from zero, in the meridian corresponding to the axis, to a maximum power (positive or negative) in the meridian at right angles to the axis. In a spherico-cylindrical lens, with both surfaces of the same kind (*i.e.*, convex or concave), the meridian corresponding to the axis of the cylinder is that of least, and that at right angles to this axis is that of the greatest (positive or negative), power. Cylindrical lenses are occasionally prescribed with two cylindrical surfaces of unequal radii of curvature and crossed axes, but the same optical effect is more easily obtained by combining a cylindrical with a spherical surface.*

Prismatic glasses with plane surfaces are of the form shown in Fig. 4326; any desired curvature, whether convex or concave spherical, or convex or concave cylindrical, may be given to either surface, or to both surfaces of the prism. A prismatic lens with one surface, or both surfaces, ground to a spherical curvature, is equivalent to a lens cut out from a peripheral zone of a larger spherical lens (Fig. 4327). Some degree of prismatic effect may, therefore, be obtained by the decentration of any convex or concave spectacle lens; such effects are, in fact, not infrequently produced by accident, as a result of carelessness in mounting spectacle glasses.

The stenopæic effect may be embodied in any lens by painting over some part of its surface, next the eye, with an opaque, lustreless, black varnish. A partial opacity of the cornea, or a portion of its surface presenting an abnormal curvature, may be thus excluded, more or less completely, from participation in the formation of the retinal image, with the effect, in some cases, of materially improving the definition of the object.[32]

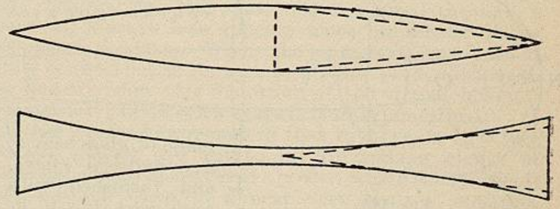

FIG. 4327.

Tinted glass is occasionally used in the manufacture of both spherical and cylindrical spectacle lenses, which, however, present an unequal density of tint in different parts, dependent on the varying thickness of the glass. In the case of concave glasses, which are thinnest at the centre, this may be an advantage; in the case of convex glasses, the inequality of tint may be avoided by cementing a thin plate of tinted glass to the plane surface of a plano-convex lens by means of Canada balsam. A more elaborate device consists in cementing a thin plate of tinted glass between the plane surfaces of two plano-convex lenses, or of a plano-spherical and a plano-cylindrical lens. Amber has been used as a material for spectacle lenses, notably at Königsberg, about the end of the seven-

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* The entire surface of revolution, as shown in section, takes one of the three forms, Fig. 4321, *a*, *b*, *c*, the last of which is an open ring (anchor-ring, torus); the interior of such a ring gives a surface (*c′*) convex in one principal meridian and concave in the other, and applicable, therefore, to the correction of mixed astigmatism.[23]

* Cylindrical lenses with two cylindrical surfaces, with axes at some angle other than a right angle, are sometimes prescribed. Such lenses, as well as bicylindrical lenses with crossed axes, can always be reduced to an optically equivalent combination of a spherical and a cylindrical surface.[31]

teenth century; the transparency of the amber is said to have been increased by heating in a bath of oil or sand.[33]

Tinted glasses are in common use to temper the light which reaches the eye; they are made either with parallel plane surfaces, like window glass, or with concentric curved surfaces, like a watch glass (coquilles). Green was formerly a favorite color, as assimilating the light passing through it to the color of grass and the foliage of trees; blue (the color of the sky) gradually superseded green, and is still often used. The neutral tint, known as London smoke, is, in most cases, to be preferred. Glasses of an amber color, called shooting glasses, are also to be found in the shops, generally ground to a dull surface, with the exception of a small, central area; they are intended to be used in looking at small distant objects in strong sunlight. Amber-colored and, more perfectly, red glasses, by excluding the more refrangible rays of the spectrum, improve the definition of the retinal image in very low grades of myopia; blue reading glasses, on the other hand, may render some slight degree of aid in low grades of hypermetropia and of presbyopia.[34] Tinted glasses should, as a rule, be mounted in large, oval rims, so as to cover the entire front of the orbit; the coquille form of glass affords more perfect protection than a glass with plane surfaces. Darkly tinted (London smoke) coquilles are of great use to persons who are exposed to strong light reflected from sand or from snow, or from the surface of water. Inasmuch as such reflected light is highly polarized, protective spectacles of tourmaline should render valuable service by cutting off the confusing reflected rays, while permitting the unpolarized light, by which objects are actually seen, to pass comparatively unobstructed.[35] London smoke glass, of so dark a tint as to appear black in ordinary light, is used in protective spectacles worn by workmen employed about electric arc lights, and spectacle glasses made up of several layers of glass of different colors have been found especially useful in observing the intensely brilliant scintillations attending the conversion of pig iron into steel by the Bessemer process. A glass smoked in the flame of a candle is a familiar device used in viewing sun spots or a solar eclipse.

All spectacles afford some degree of protection against mechanical injury, and in certain trades it is only by the use of special protectives that the liability to grave accidents to the eyes can be averted. Millers have been long in the habit of wearing large spectacles fitted with thick window glass when employed in the dangerous work of dressing millstones. Protective spectacles of mica[36] are especially to be recommended for miners, quarrymen, stone-cutters, boiler-makers, and others engaged in similar dangerous employments; large spectacles fitted with thick plates of glass or of rock crystal have been found effective as a protection against injury from stray pellets in bird shooting. Goggles of finely woven wire gauze are occasionally used by railway travellers and others as a protection against flying sparks; goggles made of glass bent to a cylindrical curve, and furnished with cushioned rims to fit closely around the margins of the orbits, also masks with glazed openings in front of the eyes, are made in a great variety of forms as protectives in driving automobiles.

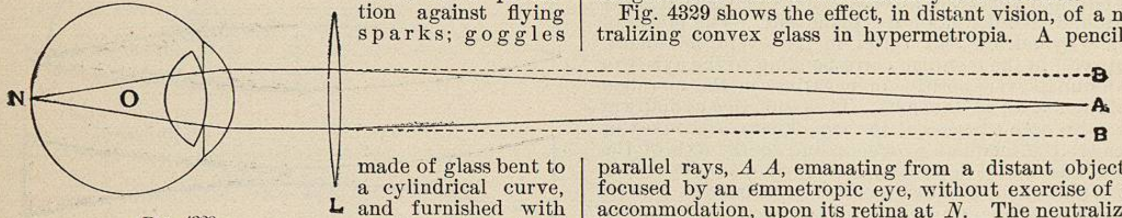

FIG. 4328.

Coquille spectacles and eyeglasses, both colorless and tinted, are made also in the meniscus form (with positive focus) and in the concavo-convex form (with negative focus); as kept in the shops, they range from about +8. dioptries to −8. dioptries. Owing to the shorter radius of curvature of the (concave) surface turned toward the eye, these glasses are more perfectly periscopic than those commonly sold under that name.

The office of spectacles and eyeglasses, other than mere protective and stenopæic glasses, is, primarily, to supplement impaired accommodation (convex glasses, in presbyopia and in accommodative paresis or paralysis), to relieve the accommodation of an excessive burden by supplementing deficient refraction (convex glasses, in hypermetropia), to correct excessive refraction (concave glasses, in myopia), to correct asymmetrical refraction (convex or concave cylindrical or toric glasses, in astigmatism), and to relieve the external ocular muscles of strain or to overcome moderate grades of diplopia (prismatic glasses). These several effects are, moreover, often variously combined, as in the use of strong convex glasses in reading (by hypermetropes with defective accommodation); of partially correcting concave glasses, or, perhaps, of weak convex glasses, in reading (by myopes with defective accommodation); of glasses of asymmetrical refraction (in compound or mixed astigmatism, and in presbyopia or other accommodative defect occurring in connection with astigmatism); and of decentrated or prismatic glasses with spherical, cylindrical, or toric surfaces.

The action of a convex glass, as used by a presbyope, in reading, is shown in Fig. 4328. Divergent rays emanating from a printed page at A, at such distance from the eye, O, that the retinal image of the print shall be of sufficient size to admit of its being easily deciphered, are refracted in passing through the lens L (whose focal length must be not less than the distance $L\ A$), and are rendered either less divergent—as if they had originated from some point more distant than A—or parallel—as if coming from an infinite distance. When the focal length of the lens L is equal to the distance $L\ A$, the rays constituting the several pencils which enter the eye, O, from an object at A, are rendered parallel, and a sharply defined retinal image is formed at N, without exercise of the accommodation. If the focal length of the lens L is greater than the distance $L\ A$, the rays forming the several pencils emanating from the object at A will, after refraction by the lens L, be rendered less divergent, as if coming from an object at some distance greater than $L\ A$, and the eye, O, will then be enabled to focus such pencils through the exercise of less of its accommodation than would be required to focus pencils diverging from A. The former of these two cases represents the condition of an emmetropic eye in extreme presbyopia, or in total paralysis of accommodation; the second case is that of an emmetropic eye in lower grades of presbyopia, or in a state of weakened accommodation.

The presbyopic eye, when thus adjusted by the convex lens L for the reading distance $O\ A$, is, by the action of the lens, thrown out of adjustment for distinct vision at a distance; a presbyope wearing glasses for reading, or other near work, must therefore remove or look over his glasses in order to see distinctly at a distance.

Fig. 4329 shows the effect, in distant vision, of a neutralizing convex glass in hypermetropia. A pencil of parallel rays, $A\ A$, emanating from a distant object, is focused by an emmetropic eye, without exercise of the accommodation, upon its retina at N. The neutralizing convex lens L converts the parallel rays of the pencil into rays of such degree of convergence that the hypermetropic eye, O, focuses them accurately at N'; the entire accommodation is thus rendered available to meet the requirements of near vision, so that the hypermetropic eye, with its neutralizing glass, becomes virtually emmetropic.

In the case of total presbyopia or paralysis of accommodation in the hypermetropic eye, a lens equal in power to the sum of the two lenses L (Fig. 4329) and L (Fig. 4328) is required for distinct vision at the reading distance $O\ A$.

A hypermetrope wearing neutralizing convex glasses sees distinctly, and without conscious effort, at all distances; when, however, he becomes also presbyopic, the neutralizing convex glasses cease to afford sufficient help in reading, and stronger glasses become necessary. These stronger reading glasses are, however, too strong for distinct vision at a distance; hence, an elderly hypermetrope requires, as a rule, two pairs of convex glasses—the one, neutralizing, for distinct vision at a distance, and another pair, of greater power, for reading.

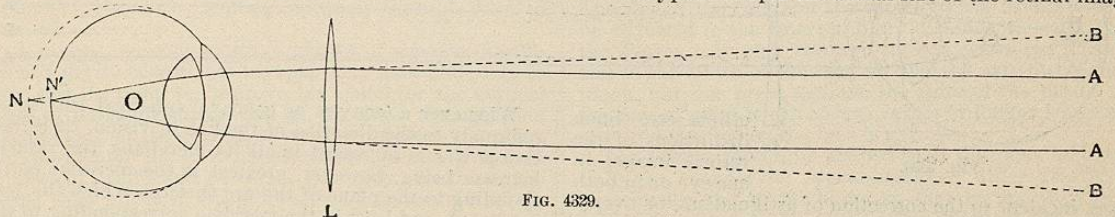

FIG. 4329.

Fig. 4330 shows the use of a neutralizing concave glass, in distant vision, in myopia. The pencil of parallel rays, $A\ A$, emanating from a distant object, is focused by the myopic, as by the emmetropic, eye at the normal position of the retina at N; the actual position of the retina, in the myopic eye, is, however, farther back, at N'. The myopic eye, in a state of complete accommodative relaxation, can focus only divergent rays, as from an object at some short distance, $O\ B$, upon its retina, and, by the exercise of its accommodation, it can also focus rays diverging from some still nearer point, somewhat within the distance of nearest distinct vision (P) for an emmetropic eye. The neutralizing concave lens, L, converts the parallel rays of the pencil, $A\ A$, into rays of such degree of divergence as they would have if emanating from B, and thus the myopic eye, O, is enabled to focus them upon its retina at N'. The farthest point of distinct vision (r) is thus carried off, by the neutralizing concave glass, to an infinite distance, and the near-point (p) is removed to the distance of the near-point in emmetropia.

When the myopic eye becomes restricted in its range of accommodation, as a result of advancing age, the neutralizing concave glasses must either be laid aside in reading or exchanged for weaker concave glasses; in myopia of a low grade it may even become necessary, in reading, to make use of convex glasses, but weaker than those which would be required by an emmetrope of the same age.

A myope wearing neutralizing concave glasses, like the hypermetrope wearing neutralizing convex glasses, sees distinctly at all distances. Only when he becomes presbyopic does he find himself compelled either to lay aside his concave glasses in reading, or to exchange them, temporarily, for weaker concave, or, possibly, for weak convex glasses.

Comparing Figs. 4329 and 4330, it will be seen that the pencil of parallel ray $A\ A$ (Fig. 4329) is of somewhat greater diameter than the pupil, and, conversely, that the pencil $A\ A$ (Fig. 4330) is of less diameter than the pupil. As the areas of the cross-sections of the two pencils are to each other as the squares of their diameters, it follows that there must be a considerable gain in the brightness of the retinal image in the case of hypermetropia corrected by convex glasses, and a loss of illumination in the case of myopia corrected by concave glasses. Thus, hypermetropes wearing convex glasses may see better than emmetropes by moonlight or starlight, and myopes wearing concave glasses see less perfectly under the same conditions; in high grades of myopia the disability from this cause is sometimes so great as to simulate night-blindness (hemeralopia).

Objects viewed through convex glasses appear larger than do the same objects when their images are focused by an exercise of the accommodation, and, conversely, near objects viewed through concave glasses under accommodative tension appear smaller than do the same objects when viewed without exercise of the accommodation. Hence a presbyope using convex glasses in reading sees the print not only clearer than without glasses, but larger than it formerly appeared to him under normal exercise of the accommodation. So, also, a hypermetrope wearing convex glasses sees all objects larger than when he views them without glasses, and a myope using concave glasses in reading sees the print smaller than when he reads without glasses. In uncorrected hypermetropia the actual size of the retinal image is smaller, and in uncorrected myopia it is larger, than in emmetropia.

A convex spectacle lens is increased in effective power by increasing its distance from the eye, and, conversely, a concave lens loses in effective power with every increase in its distance. The correct rule of practice is to mount the glasses as near as possible to the eyes, allowing sufficient room for the play of the eyelashes. A distance of 13 mm. from the vertex of the cornea fulfils this condition in most cases, and at the same time allows the correcting lens to be placed almost exactly at the anterior principal focus of the eye, in which position of the glass the retinal image, whether in hypermetropia or in myopia, becomes practically equal in size to the image of the same object when focused by an emmetropic eye. Whenever a hypermetrope inclines to remove his (convex) glasses to a greater distance from the eye than 13 mm., it may generally be assumed that the glasses are somewhat too weak, and, conversely, when a myope inclines to wear his (concave) glasses at a distance greater than 13 mm. from the eye, it may be assumed that the glasses are somewhat too strong. In presbyopia it is a not uncommon habit of old people to wear their spectacles far down toward the tip of the nose, in order to make a weak glass do the office of a stronger glass in improving the distinctness of the print, and also in increasing its apparent size; in this position of the glasses it is also easy to look over them at distant objects. In aphakia, after an operation for cataract, recourse may be had to the same expedient, as affording a partial substitute for the lost accommodation.

The increase or diminution in the apparent size of objects viewed through a convex or concave spectacle lens is not uniform in all parts of the visual field, but is greater at its periphery than at its centre. Thus, a large object viewed through a spherical convex lens appears more highly magnified in its peripheral than in its central portions, and the same object viewed through a spherical concave lens appears more diminished in its peripheral portions. When the (spherical) lens is accurately centred before the eye, in a plane perpendicular to the line of vision, this distortion of the virtual image is symmetrical; in all other cases it is unsymmetrical.

It has been often remarked that myopes, in selecting concave glasses, are apt to err by making choice of glasses of somewhat excessive power, which cause objects seen through them to appear very sharply outlined. This phenomenon appears to be a result of the chromatic aberration of the eye, causing the object, when viewed through a concave glass under a full correction for the more highly refrangible (blue or violet) rays of the spectrum, to be seen as if bounded by a very narrow red border, instead of by a broader violet fringe, as when the eye is focused for the less refrangible (red) rays. If a distant point of light is viewed by an over-corrected myopic eye through a piece of cobalt-blue glass, the light will appear blue, with a narrow red border; if the eye is