of bronchitis with many patients before the malady has become too chronic, as that subject is to be fully discussed under its proper head.

Peptic asthma is so much influenced by the state of the alimentary canal that some have spoken of the treatment of asthma in general as if it were mainly a matter of regimen and diet. Indigestible food, even a single meal of such, is to be scrupulously avoided in every form of spasmodic disease. The patient must not endeavor to reconcile his digestive apparatus to any second trial with an offender. Whether the proneness to spasmodic or convulsive disorder be due here to the greater susceptibility of the nerve centres to reflex excitation from the alimentary canal than from any other nerve distribution, or whether the susceptibility is caused by the absorption of nerve poisons generated in some intestinal fermentation, it is unquestionable that any departure from good digestion is to be dreaded in treating such complaints, and in none more so than in asthma. Experience will best teach each one all the particulars as regards what he can and what he cannot eat, and its verdict must be accepted. Moreover, with all asthmatics, the digestive power decreases as the day wears on, and hence the best meal should be taken before the afternoon, while in the evening only the lightest supper should be allowed.

But as the prevention of peptic asthma wellnigh involves the treatment of all the varied forms of dyspepsia, we can direct attention here only in a general way to the subject, for each case is to be managed according to its own indications. We may remark, however, that bismuth appears to be one of the most effective preventives of peptic asthma, probably owing to its antiseptic properties. A good form of administration is in capsules of five grains each of bismuth. carb., and of pulv. calumbæ, two such to be taken an hour after meals and at night. Ten grains of sodium benzoate and ten grains of bismuth salicylate, administered in two capsules, will also often be found effective in preventing intestinal fermentation.

In conclusion, we would recommend, besides prophylactic measures, the recourse to certain remedies whose benefit, when secured, can properly be termed lasting or curative, instead of merely palliative. Want of success with them may be due often to a failure to recognize the fact that to be truly curative in such a deepseated and lifelong malady as asthma a remedy must be given continuously without reference to the attacks, and long enough to produce a decided modification in the system itself. Such a result never can be obtained from nervines, however steadily or largely they be taken, as is proved by the absence of any recognizable sign, either during life or after death, of the years spent by many in consuming tobacco or opium. In arsenic and the potassium iodide, however, we possess truly constitutional medicines, whose value in asthma has been repeatedly demonstrated. If these medicines, however, have any effect on asthma, that effect is wholly different in kind from the immediate relief produced by a transient-acting nervine, for it must be by causing a more or less organic alteration in the lesion itself. Their proper administration in asthma, therefore, should be like the administration of iron for anæmia, or mercury for syphilis, or the bromides for epilepsy, the effect being obtained not by one, or by the first dose, but only after months of steady use. I feel assured that if a combined or alternate arsenical and iodide treatment were as systematically adopted in the treatment of asthma as the above-named constitutional remedies are used in other maladies, many a case of this disease would be finally got rid of which now, under the deceptive recourse to nervines, becomes at last an incurable habit of the nervous respiratory mechanism.

To obtain the best results with constitutional remedies, two therapeutical rules should be steadily followed. The first is to administer along with them one or more of the restoratives, in order to prevent the injurious effects of the continued taking of such unnatural substances into the system as arsenic or iodine. No symptoms of iodism or of arsenic should be allowed, because the remedial effects of these medicines cease at once upon the appearance of any signs of their poisonous operation. If diminishing the dose is not followed by a cessation of the symptoms, these drugs must be omitted for a time, and then resumed in small doses, to be increased again only as the patient can tolerate them. The best restoratives with arsenic are quinine and codliver oil, while phosphorus and the muriated tincture of iron best prevent the injurious effects of iodine.

The second rule is to secure the co-operation of nervines, for though these latter cannot be curative in themselves, yet experience proves that they unquestionably promote the action of constitutional remedies when they relieve some of the symptoms of the disease. Thus I have repeatedly noted potassium iodide fail adequately to cure a syphilitic node until opium and conium were added to the prescription. And on the same principle I have been accustomed in asthma to prescribe a combination somewhat as follows: ℞ Kal. iodid., ʒ iss.; Liq. pot. arsen., ʒ i.; Spts. eth. sulph. co., ℥ iiss., Tr. belladonnæ, ʒ ij.; Spr. aurant. cort. ad ℥ vi. M. S.: Two teaspoonfuls in water an hour after meals.

In a certain proportion of cases a curative effect is secured by counter-irritation applied along the cervical and upper dorsal vertebræ. The actual cautery is to be preferred, and one form of this irritation is both effective and readily applied without expensive apparatus, namely, by the hot glass rod. Spots of ink, half an inch or so apart, made along the spinous processes, are to be lightly touched by the tip of a glass rod raised to a white heat in the flame of an alcohol lamp. This simple procedure causes but little pain, and immediately after the application shows a continuous red line as if made by the passage of a hot iron. The application should be repeated about every fourth day.

If there is any history of the alternation of asthma with the disappearance of a cutaneous eruption, an artificial eczema by croton oil on the chest, as already mentioned, is often positively remedial if persevered in on the first sign of a return of the dyspnœa. Asthma secondary to other diseases must be treated with them. In the cardiac cases, and in gouty patients as well, a continued use of saline waters, like the Congress or Hathorn of Saratoga, will afford the best prospect of relief.

In all cases of asthma, however, a careful examination of the nasal passages should be made at the beginning and repeated throughout the treatment. The innervation of the outlets of all long tubular tracts is closely associated with the nervous mechanism controlling the muscular movements of the whole tract, examples of which are seen in the heightened irritability of the whole genito-urinary apparatus by a narrowed meatus, or orifice of the prepuce, by the pylorus remaining patent so that the stomach is too quickly emptied in dysentery, etc. We need not wonder, therefore, if the normal rhythm of respiration is readily deranged by a polypus or other obstruction in the nose, and all such conditions should be fully remedied when found. But aside from such lesions, many asthmatic attacks may be prevented or aborted early by a spray of carbolized oil—one part of carbolic acid to forty of sweet almond oil—used especially on retiring at night.

William H. Thomson.

ASTIGMATISM* (from *a*, privative, and *στίγμα*, a point) is the name proposed by Whewell (1846) to designate the visual anomaly which results from unequal refraction in the planes of the several ocular meridians.† Accurate measurements of the cornea reveal, in the greater number of eyes, a somewhat different radius of curvature in different meridians, and not infrequently this difference is sufficient to give rise to serious imperfection of vision. As a rule, the meridian of greatest curvature is vertical or approximately vertical, and the meridian of least curvature, at right angles to the former, is horizontal or approximately horizontal. To this rule there are, however, many and conspicuous exceptions.

* The form "*astigmia*," *cf.* "*presbytia*" = *presbyopia*, has been lately adopted by certain French writers.

† For convenience, the familiar system of lines and circles used in geography is extended to the topography of the eyeball. If we designate the centre of the cornea and the central fovea of the retina as the anterior and posterior poles, respectively, the line connecting them is the axis; all great circles passing through the two poles are meridians; the great circle which cuts all the meridians midway between the poles is the equator; and the portion of the surface included between any two parallels is a zone.

The crystalline lens, also, may be the seat of asymmetrical refraction, either through inequality of curvature in its several meridians, or through some deviation from perfect symmetry of position as referred to the axis of the eyeball. Astigmatism of the crystalline lens is generally of comparatively low grade, and the meridian of greatest lenticular refraction is oftenest approximately horizontal, rather than vertical. Hence lenticular astigmatism tends oftener to correct than to increase the astigmatism due to asymmetry of the cornea, and the total astigmatism of any eye is apt to fall short of rather than to exceed that which would result from the corneal asymmetry alone.

From the fact that neither the cornea nor the anterior or posterior lens surface is a perfect surface of revolution, and that not one of these surfaces is quite accurately adjusted with reference to the axis of the eyeball, it follows that the refraction, whether symmetrical or asymmetrical, in any eye is actually the resultant of three more or less asymmetrical refractions. In practice, however, these complications are disregarded, and the investigation of the elements of any case of astigmatism is limited to the measurement of differences in the curvature of the cornea in different meridians and to the study of the refractive phenomena as a whole.

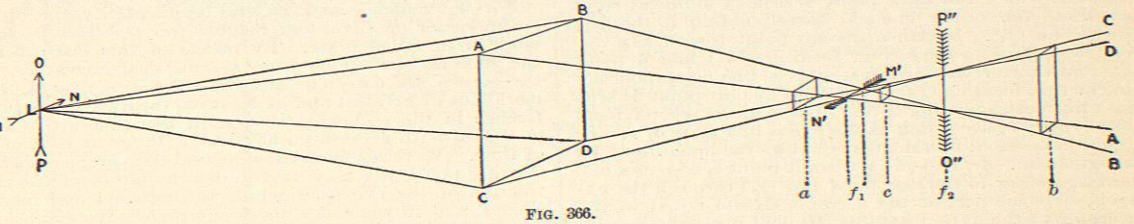

FIG. 366.

The characteristic property of a pencil of light after a single astigmatic refraction (or reflection) is that it has no focus, properly so called, but that all its rays pass through two nearly straight lines, which lie at right angles to the axis of the pencil and to each other (*focal lines*). The construction of such a pencil is shown in Fig. 366, in which L represents a luminous point; A, B, C, D a portion of an asymmetrical refracting surface (cornea), of which the meridian of greatest refraction is assumed to be vertical, and which for convenience in representation is taken as a square; f_1 the first focal line; and f_2, lying in a direction at right angles to the first, the second focal line. The form of the cross section of the pencil at other parts of its course after refraction is indicated by the three parallelograms, *a*, *c*, and *b*. Only one of these cross sections (*c*), lying between the two focal lines but nearer to f_1 than to f_2, has the same form as the cross section of the pencil before refraction (namely, a square); all the others are parallelograms, having their longer sides in a direction parallel to the nearer focal line. The distance separating the two focal lines (f_1 and f_2) is called the *focal interval*.

From the construction it follows that if the pencil is cut by the retina at f_1, the luminous point at L will be seen as a horizontal bright line, and, similarly, if the pencil is cut at f_2, the point L will be seen as a vertical line. If the pencil is cut by the retina at *c*, the point will be seen as a small spot having the form of the refracting surface, which, in the eye, is determined by the form of the pupil, and is therefore approximately circular. If the pencil is cut at any other part of its course the point will be seen as an oval closely approximating an ellipse. The section of the pencil at *c* is called the *circle of least confusion*.

If, instead of a single luminous point at L, we assume a number of points arranged along the horizontal line M L N, these points will be severally projected at f_1, each as a horizontal line, and these lines, overlapping each other in the greater part of their length, will appear fused into a single horizontal line. It follows that the line M L N, which may be regarded as made up of an infinite number of points, will be projected as a horizontal line at f_1. So also a series of points arranged along the vertical line O L P, or the vertical line O L P itself, will be projected as a vertical line at f_2. Lines lying in one or the other of these two directions (parallel to M L N or to O L P) are, in fact, the only objects which can be projected by the asymmetrical refracting surface without conspicuous alteration.

The line M L N and the first focal line f_1 lie in the same plane; similarly the line O L P and the second focal line f_2 lie in a plane at right angles to the former plane. The intersections of these two planes (*principal planes*) with the refracting surface mark the meridians of least and greatest refraction (*principal meridians*), which are also at right angles to each other. It is sufficient, therefore, in any case to note the direction of one of the principal meridians, preferably the meridian of greatest refraction, which, in the case of the cornea, is designated by the symbol M_c.

The phenomena characteristic of astigmatic refraction may be shown experimentally by means of a lighted candle, an ordinary convex lens, and a convex plano-cylindrical lens.* The image of the distant candle flame, which may be considered as equivalent to a luminous point, is first received upon a screen placed at the principal focus of the spherical lens, where it will appear as a bright point. If now the convex cylindrical lens is placed immediately in front of or behind the spherical lens, this bright point will be seen drawn out into a bright line representing the second focal line (f_2), and by moving the screen nearer to the combined lens a distance will be reached at which the bright point will be seen drawn out into a line at right angles to the first, representing the first focal line (f_1). In moving the screen from the position of the second to that of the first focal line, a point will be passed at which the illuminated area is seen expanded into a small circular bright spot, reproducing the circular outline of the lens (circle of least confusion); at all other distances the section of the pencil will be elliptical in form, with the longer axis of the ellipse in the direction of the nearer focal line.†

To study the phenomena of astigmatic vision, it is only necessary to look through a weak cylindrical lens held before the eye or mounted in a spectacle frame. If the eye is emmetropic (see *Accommodation and Refraction*), a convex cylindrical lens will render it short-sighted (myopic) in the meridian at right angles to the axis of the cylinder, and, conversely, a concave cylindrical lens will render it over-sighted (hypermetropic) in the same

* A plano-cylindrical lens has one surface plane and the other ground to a cylindrical curvature, which may be either convex or concave. Lenses are also ground with a convex or concave spherical surface on one side and a convex or concave cylindrical surface on the other side, and may be imitated by cementing together, by their plane surfaces, an ordinary plano-convex or plano-concave lens and a plano-cylindrical lens. Such a combined lens is called a spherico-cylindrical lens.

† If instead of a candle flame a very bright light is used, such as an electric arc or calcium light, or a beam of sunlight directed by means of a mirror through a small hole in the window shutter, the form of the pencil may be seen lighting up the dust of the room along its entire course.

meridian; thus reproducing the two types of simple astigmatism, namely, *simple myopic astigmatism* (Am) and *simple hypermetropic astigmatism* (Ah). If the eye is myopic, or is made so for the experiment by means of a convex spherical lens, the convex cylindrical lens will render it more myopic in the meridian at right angles to its axis; and, similarly, if the eye is hypermetropic, or is made so by means of a concave spherical lens, the concave cylindrical lens will render it more hypermetropic in the meridian at right angles to its axis; thus reproducing the two types, *compound myopic astigmatism* (M + Am), and *compound hypermetropic astigmatism* (H + Ah). A fifth type, called *mixed astigmatism* (Amh or Ahm), is reproduced in the emmetropic eye by looking through a convex or concave spherical lens combined with a concave or convex cylindrical lens of greater power; in the myopic eye, by looking through a concave cylindrical lens of a power in excess of the degree of the myopia; and in the hypermetropic eye, by looking through a convex cylindrical lens of a power in excess of the degree of the hypermetropia. These five types include all the possible varieties of regular astigmatism.

In M + Am all distant objects appear confused and indistinct, but there is a certain distance at which a point is seen under the form of a line corresponding to the second focal line (f_2), and there is a second, shorter distance at which the same point is seen as a line at right angles to the former line and corresponding to the first focal line (f_1). In Am a distant point is seen as a line corresponding to the second focal line (f_2), and a point at some shorter distance is seen as a line corresponding to the first focal line (f_1). In Ah a distant point is seen as a line corresponding to the first or to the second focal line (f_1 or f_2), according as the eye is in a state of rest or is accommodated to a degree equal to the measure of its astigmatism. In H + Ah a distant point is seen as a line corresponding to the first focal line (f_1) through the exercise of some part of the accommodation equal to the measure of the hypermetropia (H), and it may be seen as a line corresponding to the second focal line (f_2) through a greater exercise of the accommodation equal to the sum of the hypermetropia (H) and the astigmatism (Ah). In mixed astigmatism (Amh or Ahm) a distant point is seen as a line corresponding to the second focal line (f_2) through the exercise of some part of the accommodation, and a point at some shorter distance is seen as a line corresponding to the first focal line (f_1).

In any case in which a point is seen under the form of a line, all lines at the same distance which correspond in direction to the direction of this linear image will be seen sharply defined. Hence the visual phenomena in astigmatism may be studied by the use of test objects made up either of points or rows of points, or of lines or sets of parallel lines. Examples of such test objects are

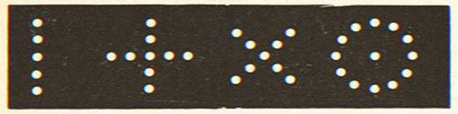

FIG. 367 *a*.

FIG. 367 *b*.

shown in Figs. 367 and 368, both as they are seen by the normal eye when accurately focussed for their distance, and as they appear to an astigmatic eye when similarly adjusted in its vertical meridian. In Fig. 367 *b* every dot is seen elongated and blurred in the horizontal direction, so that the dots in the horizontal rows appear to run into one another, while in the vertical rows they are seen distinctly separated. Similarly the horizontal lines in Fig. 368 *b* are seen sharply defined, although somewhat elongated, while the vertical and oblique lines appear blurred.

In the diagnosis of astigmatism, as of ametropia generally, both objective and subjective methods are employed. In the examination of the eyes of very young

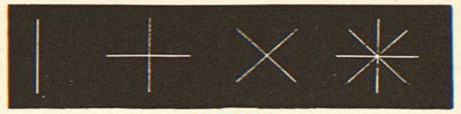

FIG. 368 *a*.

FIG. 368 *b*.

children objective methods are alone available, and in nearly every case they give direct and valuable information by quickly and surely revealing special refractive defects and indicating the way to their further investigation.

For convenience and general applicability the ophthalmometer of Javal and Schiötz (see *Ophthalmometer*) holds a foremost place. By means of this instrument the smallest deviations from symmetrical curvature of the cornea are detected, and both the direction of the meridians of greatest and of least curvature and the difference in the corneal refraction in these meridians are measured with great accuracy and with great economy of time. Working from these corneal measurements as a starting point, the way to the determination of the refraction of the eye as a whole is shortened and made clearer, and in the end a more comprehensive diagnosis is reached than is possible when the corneal astigmatism is ignored as a distinct factor.

The ophthalmoscope is used in several different ways for the detection and measurement of refractive anomalies, including astigmatism. In viewing the fundus of the eye in the erect image (see *Ophthalmoscope*), the details of the picture of the retinal vessels and optic disk are affected in the same manner as are the images of visible objects when viewed by an ametropic eye. In astigmatism the retinal vessels afford, to the observer, test objects not unlike the radiating lines shown in Fig. 368; the determination of the refraction in the two principal meridians is made by noting the strongest convex or the weakest concave lens through which the observer sees distinctly the vessels which lie at right angles, respectively, to the direction of these meridians. In the higher grades of astigmatism the fundus of the eye presents a very characteristic picture of a confused red ground marked by parallel streaks of a deeper red, in which the double contour of a retinal vein or artery is here and there recognizable, and by a lighter spot, the optic disk, which is seen elongated and blurred in the same direction. The inspection of the details of the fundus is best made with the ophthalmoscope devised for this purpose by Loring, in which a revolving disk (or disks), containing a large series of convex and concave lenses, is mounted immediately behind the mirror. To secure a good observation it is often convenient, and sometimes necessary, to dilate the pupil, but not, as a rule, to paralyze the accommodation. Cocain hydrochlorate (three per cent.) and euphthalmin hydrochlorate (five per cent.), or a solution of the two salts (one per cent. each),* afford a choice of mydriatics which best fulfil this indication.

Another application of the ophthalmoscope to the investigation of the refraction is by the method known as retinoscopy, shadow test, etc., which consists essentially in the observation of the direction in which the dark

* As recommended by E. Jackson.

border of the image of a flame, reflected into the eye by the mirror, moves across the strongly illuminated pupil (see *Shadow Test*). By this method measurements of the total refraction of the eye, and, in astigmatism, of the direction of the principal meridians and also of the refraction in each of these meridians, may be made with a fairly close approximation to accuracy. Preliminary dilatation of the pupil is always a help, and is often indispensable; cocain hydrochlorate and euphthalmin hydrochlorate are to be preferred for this purpose. For the indication of other methods by which the ophthalmoscope may be helpful in the detection and investigation of astigmatism, see *Ophthalmoscope*.

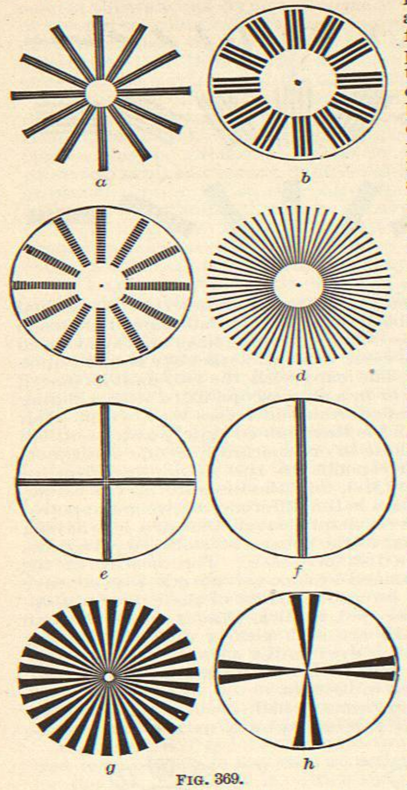

FIG. 369.

The subjective investigation of astigmatism is most directly and easily conducted by the use of special test diagrams similar to the test objects shown in Figs. 367 and 368. A few examples, selected from a much larger number which have been devised for this purpose, are shown in Figs. 369, *a* to *h*. They are printed on circular cards, about nine inches in diameter, and, for greater convenience in use, and to meet the varied conditions in different cases, they are drawn to different scales; the finer lines are easily distinguished by a normal eye at a distance of about eight metres. The several cards are made with a central hole, so that they may be made to turn on a pivot at the centre of a larger card representing a clock dial. This dial card is hung on the wall, in a good light, and the tests are viewed from the opposite side of the room at a distance of about five or six metres. When an astigmatic eye is directed upon one of the diagrams made up of radiating lines or sets of lines (Fig. 369, *a* to *f*) or of narrow sectors (Fig. 369, *g*, *h*), the lines or sectors which correspond in direction to one of the two principal meridians are generally seen more sharply defined than those in the other meridians. In simple myopic astigmatism (Am) the line or lines corresponding in direction to the ocular meridian of greatest refraction (M_o) are seen clearly defined, while those in the other meridians appear indistinct or confused. In mixed astigmatism (Amh or Ahm) the lines which correspond in direction to the meridian of greatest refraction are distinguished through an exercise of the accommodation equal to the measure of the hypermetropic part of the refractive anomaly, while those in the other meridians are seen indistinctly. In simple hypermetropic astigmatism (Ah) the lines corresponding in direction to the ocular meridian of least refraction (at right angles to M_o) are seen distinctly when the eye is in a state of accommodative rest, and these lines become confused, while those corresponding in direction to the meridian of greatest refraction (M_o) become in turn distinct, when the accommodation is exerted to a degree equivalent to the measure of the astigmatism. In compound hypermetropic astigmatism (H + Ah), the lines in the former or in the latter of these meridians are seen sharply defined, through an exercise of the accommodation equivalent in the one case to the measure of the hypermetropia (H), and in the other case to the measure of the combined hypermetropia and astigmatism (H + Ah). Only in compound myopic astigmatism (M + Am) do the lines necessarily appear indistinct in all meridians, although least so in the meridian of greatest ocular refraction; when the myopia (M) is corrected, by placing a suitable concave lens in front of the eye, the case is transformed into that of simple myopic astigmatism (Am).

In the hypermetropic forms of astigmatism (Ah, and H + Ah), and also in certain cases of mixed astigmatism, the examination is rendered difficult by unconscious accommodative efforts of the patient in the attempt to recognize as many as possible of the test lines. To overcome this difficulty it is generally necessary to suppress the accommodation for the time being, which may be accomplished by placing before the eye a convex glass of sufficient strength to correct it in its meridian of least refraction; in other words, bringing the eye into the condition of simple myopic astigmatism (Am), by making it look through the strongest convex glass through which it can clearly distinguish the lines in any meridian. The disturbing influence of the accommodation may also be annulled by means of a solution of atropia, several times instilled, until the accommodation becomes completely paralyzed. This involves, however, a serious disturbance of vision, which may persist for many days, and also the special disadvantage of enlarging the pupil far beyond its normal diameter, and so including in the measurement a peripheral zone of the cornea and of the crystalline lens, in which the curvature may differ materially from that in the central region which alone is ordinarily utilized in vision.*

In the investigation of any case of ametropia by this method, we first select, by successive trials, the weakest concave glass (in M + Am) or the strongest convex glass (in Amh or Ahm, Ah, and H + Ah) through which the lines in any meridian are clearly distinguished. If the lines in all the meridians are seen through this spherical glass with perfect distinctness, astigmatism is excluded. If the lines in only one meridian are distinctly recognized this meridian will be the ocular meridian of greatest refraction (M_o), and the glass through which the lines are seen will represent the measure of the ametropia (M or H) in the ocular meridian of least refraction. When these two elements have been determined, it remains only to ascertain the degree of astigmatism, by successive trials with concave cylindrical glasses, until a glass is found through which (when added to the spherical glass already chosen) the lines in both principal meridians are seen clearly. This cylindrical glass is the measure of the astigmatism.

Proceeding in this manner, we obtain a formula in terms of M + Am, Am, or H + Am; the symbol M + Am being that of *compound myopic astigmatism*, and Am that of *simple myopic astigmatism*. In the expression H + Am, we may have H = Am, in which case the expression reduces to Ah, which is the symbol of *simple hypermetropic astigmatism*. When H > Am, the expression H + Am is transformed into H + Ah, the symbol of *compound hypermetropic astigmatism*, by taking H equal to the difference in the numerical values of H and Am and changing Am to Ah. When H < Am, the case is one of *mixed astigmatism* (Amh or Ahm), and the expression H + Am

* Measurements of the refraction made under artificial paralysis of the accommodation ought never to be adopted as final until they have been verified, or corrected, by other tests made after the last traces of mydriasis have disappeared.