

diaphragm itself. Patients, on this account, especially dread to laugh or to do anything which slows or checks the relaxation of the diaphragm, such as long talking. But how these actions could in any way affect bronchial constriction is difficult to conceive.

On the other hand, there is one incontestable proof that constriction of the bronchi does take place in every case of real asthma, and that is the invariable presence of general sibilant râles of every variety of size, from fine whistling to large cooing sounds. In true asthma these sounds are purely tubular, and from their shifting character, above alluded to, it is plain that they are produced by progressive waves of contraction in the bronchial walls, and not by a uniform diminution of their calibre, such as general tumefaction (Weber) would occasion. These râles, moreover, are simultaneous with the onset of the attack, as they are audible sometimes in the breathing of an asthmatic, even before he is awakened by a fit, and so constant are they that no dyspnoea can be termed asthmatic if there be no wheezing. Now, the theory of diaphragm spasm wholly fails to account for these characteristic bronchial râles. If we had diaphragm spasm alone, the symptoms then would rather resemble *burking*, or, more properly, the dyspnoea which is often the fatal complication of tetanus, in which disease death results from tonic spasm of the respiratory muscles. Here, as I have had personal occasion to note, there is no wheezing whatever.

From these considerations the view of Lebert seems to us preferable, namely, that the asthmatic paroxysm begins with spasm of the bronchial muscles, much as the first discharge of epilepsy often begins with a special group of muscles, and then spreads to other and wider muscular associations. Considering how intimately and constantly the muscular actions of respiration are associated, it is easy to conceive how disordered innervation of the bronchial muscles may become quickly accompanied by disordered innervation of the diaphragm, and thus check the return of inspired air. Some ten such respirations would suffice to inflate the lungs to the extreme degree observable in asthma, until the whole muscular apparatus of expiration would join in the spasm and complete the picture of this dyspnoea, in which condition almost the only movements which remain in the distressful breathing are the lifting actions of the neck and shoulder muscles. Lebert justly insists on the contrast between the pulmonary dilatation in asthma and its absence in fibrinous bronchitis, in which disease, though the obstruction is great and the constriction of the bronchioles a tubular narrowing, yet there is but slight, if any, dilatation; which proves, therefore, that something more than bronchial constriction is needed to explain all the clinical features of asthma.

TREATMENT.—Much the greater number of reputed remedies for asthma are little else than palliative, because their operation merely relieves a paroxysm or attack of the complaint, just as opium may relieve the pain of a syphilitic node without producing the least effect on the cause of the symptom itself. The peculiar motor spasm of asthma is not the disease, but only a symptom of it, the same in nature with pain, and hence, like other mere symptoms in nervous diseases, it can be affected by a great variety of influences. Thus, such unlike agents as caffeine, chloral, ether, and tobacco, or the inhalation of stramonium or of nitre fumes, are each spoken of as marvellously relieving certain confirmed asthmatics. No sooner does the patient begin to experience the special effects which these drugs produce in a healthy man than the agony of his breathing subsides, and a restful calm succeeds as by magic. But the great disappointment with these seemingly effective remedies is that the longest use of them brings the patient no nearer getting rid of his enemy than when he began. He may break up his attacks for years with his special prescription, but the asthmatic fit is as ready to return, and as severely, as if no remedy for it ever had been tried.

The reason for this failure is fundamental. These so-called remedies for asthma are all nervines, and no agent

like opium, or aconite, or stramonium, or ether, whose whole medicinal action is obtained by one dose, can do anything more than that one dose does. However often repeated, no cumulative progressive effect follows upon the administration of nervines, and hence they can affect only the functional manifestations of a constitutional disease. All that such medicines can do is to produce some immediate but temporary change in some symptom of the complaint, but no more. There is hence a parallel between the curious variety of the exciting causes of asthma in different persons and the like variety both in the nervines themselves and in their disproportionate efficacy in different patients. For while the exciting causes show by their incongruity that they are not true but only accidental elements in the case, so the diverse nervines recommended for asthma show that they affect only some accessory but not essential factor in the disease. When a nasal polypus makes one patient an asthmatic and a loaded rectum another, neither of these cases throws the least light on the true cause of asthma. Likewise when a nauseant emetic and a glass of hot spirits and water are each said to "work like a charm" in some asthmatics, we can scarcely say of such remedies that they bring us nearer the true therapeutics of the malady, for it is plain that they modify only some chance association of perverted function.

In this class of palliative remedies we would assign the first place to the mydriatics, belladonna, hyoscyamus, stramonium, and duboisin. The wide range of disorders in which these medicines have been found beneficial is due to a general principle in their operation, which also suggests the explanation of their use in asthma—viz., that they relieve disordered innervation of involuntary muscular fibre by a motor stimulant action which restores its rhythmical contraction when it has been arrested by spasm from any cause. Spasm and paralysis are associated phenomena in unstriated muscle, tetanic contraction of one portion and relaxation of the remainder taking the place of the normal wave movement throughout the whole. Hence the use of belladonna and its allies in spasmodic action of the bladder in cystitis, in nocturnal incontinence of urine, in the constipation of women from reflex pelvic irritation, in spasmodic gastrodynia, in cardiac pains when due to left hypertrophy deranging the rhythm of the two sides of the heart, etc. As with other nervines, the earlier they are given in the attack the more pronounced and speedy is the effect. A full dose of the tincture or of the fluid extract of belladonna should be given, enough to produce well-marked constitutional effects, and then the dose should be repeated in two hours if there be only imperfect relief. If the second dose fails to affect the breathing, a very effective method is to give a hypodermic of atropine injected deeply into the nape of the neck, a locality which is the seat of a sensation of great weariness in severe attacks of asthma, and which this measure often mitigates at once, after other employment of the remedy has failed. Hyoscyamine sometimes affords more relief than atropine, but in most cases is not superior to it. Other patients are best relieved by the inhalation of the smoke of stramonium leaves, for which purpose they may be lit at the bottom of a cup, or used like tobacco in a pipe, or made into cigarettes; the effort being to inhale the fumes as deeply as possible, when the dyspnoea sometimes is found to vanish with surprising rapidity.

Coffee should be reckoned also among the nervines which are effective in asthma by a stimulant action. It should be made very strong, taken always on an empty stomach and taken hot, for the sipping of the potion is not without its own effect, as it has been shown by Kröneckner that the act of swallowing itself powerfully stimulates the cardiac and pulmonary branches of the vagus. Coffee taken after eating aggravates asthma by interfering with digestion. In some cases I have found the alkaloid caffeine of temporary benefit, but on the whole I regard it as inferior to the freshly made and strong infusion. Hot coffee is particularly good in asthmatic bronchitis, as it facilitates the expectoration while it re-

lieves the spasmodic condition. It is in the same class of cases, also, that the muscle stimulant, nux vomica, is sometimes beneficial. Here again the tincture or the fluid extract of the drug is preferable to its alkaloid, strychnine.

Next in order come the nervines which probably relieve the asthmatic paroxysm by a sedative action on the initial irritant impression. Among these we would enumerate alcohol, the ethers, chloral, and opium. It should be noted that while alcohol is a stimulant to the heart and to some cerebral functions, it is an immediate sedative to the sensory nerves, and this sedation steadily increases in proportion to the dose. Sulphuric ether, when taken internally, resembles alcohol in these respects, though its sedative effects are much more pronounced. Hence the use of both alcohol and ether in the muscle cramp of intestinal colic and in spasmodic affections of ducts generally. Full doses of spirits, therefore, taken hot, will relieve some asthmatics to the exclusion of all other remedies; but the relief does not occur generally until enough is taken to intoxicate a well person, though it rarely does so with an asthmatic. Sulphuric ether, however, is much more generally effective, especially in the preparation of the Spiritus Compositus, or Hoffman's anodyne, owing to the oil of wine which it contains. As this latter ingredient is expensive, it is sometimes fraudulently omitted, with a plain falling off in remedial power over the attacks. The dose for the paroxysm should be not less than two drachms. As the latter acts in a different way from the belladonna (being more connected with the sensory element of the spasmodic condition, while the belladonna affects the motor), an unquestionable gain is secured by administering these two remedies together.

As might be expected, there is much contradictory testimony about the value of opium in asthma. This need not be wondered at in view of the widely different effects of opium, *e.g.*, as a soporific, in different individuals. The mode of administration, however, counts more with this remedy than with any other, for the speedy effect of a hypodermic of morphine is much oftener successful than morphine or opium taken by the mouth. This, however, is in accordance with the general rule that the more quickly a nerve is felt, the more effective it is against any spasmodic affection—*e.g.*, arresting an epileptic fit by a sudden irritant impression, but which it fails to do if applied gradually. Chloral in large doses, thirty to sixty grains, is claimed as an excellent remedy for asthma; but the patient's tolerance of this drug, sometimes fatal in only fifteen-grain doses, should be well established before this treatment is tried. Inhalations of nitrite of amyl often arrest a commencing attack, but are not of much use in a fully developed paroxysm. The fumes of the nitrate of potash, however, inhaled by burning cigarettes made of rice paper dipped in a saturated solution of the salt and then dried, are much more generally effective. This remedy undoubtedly acts by virtue of the well-known locally sedative properties of potash itself, and hence may well co-operate with the different action of the fumes of stramonium leaves rolled up with the nitre paper.

Lastly, we have the pure sedatives whose action cannot be secured until nausea has been occasioned by them. Asthmatic spasm, like every other cramp, rarely holds out against the sickening effect of tobacco, lobelia, or even of ipecacuanha. Tobacco, therefore, is effective only with those who are not used to it. Lobelia has the disadvantage of producing too much prostration, and the same may be said of tartar emetic. This class of remedies works much better in bronchitic than in peptic asthma.

Besides these there are but few nervines left in the pharmacopœia which are not recommended by some for asthma, although no one is ever permanently benefited by any of them.

Better results, however, may be hoped for from efforts directed to other aims than simply to relieve a fit of the dyspnoea when present. Asthma is at no time absent from the asthmatic any more than epilepsy from the

epileptic, though the manifestations of either are only occasional. Prophylaxis, therefore, assumes an exceptional importance, because, as in other spasmodic neuroses, the malady becomes inveterate in proportion to the frequency of the attacks. As in the case of epilepsy also, the slightest attacks of asthma are as much to be avoided as the severer ones, if there is to be any hope of the patient becoming ultimately free from them, and hence the exciting causes in each instance should be carefully noted and jealously provided against. In those cases in which the susceptibility to odors indicates the upper respiratory tract as the seat of the irritability, the inhalation of carbolic steam should be tried. The steam should be made to surround the head by the simple device of directing it under an umbrella, held low by the patient himself, so that he may inhale without more effort than in ordinary respiration, because breathing by will is too fatiguing a task to be kept up for long by any one, and it is this fact which accounts for the uniform failure of the many inhalers and atomizers which have been invented during the past century. This treatment should be kept up twice a day for months, the object being to produce a permanent change in the susceptibility of the sensory nerves distributed to the nasal and pharyngeal mucous membranes. Occasionally the vapor of turpentine may be substituted for that of carbolic acid. It is in these cases also that much may be expected from the French procedure, originated by Ducros, of painting the posterior wall of the pharynx with aqua ammonia, although, to prevent some being made worse by the irritant fumes, Trousseau recommends inhalations of ammonia first from a vial and then touching the pharynx with a weak solution, to be made stronger as the patient becomes accustomed to it. Trousseau refers the immunity of many patients from visits of asthma so long as they reside in the vicinity of gas-works to the presence of ammonia in the air of the locality; but while this possibly may be operative, yet we would ascribe it more to the unmistakable sedative effect upon the bronchial nerves of air charged with creosote, carbolic acid, and other allied products of wood distillation. It is in this class of patients also that the bromides are useful, owing to their paralyzing the reflex excitability of the pharyngeal nerves. A dose of thirty grains of potassium bromide, with a drachm of Hoffman's anodyne at bed-time, will often ward off a nocturnal visit of the enemy.

It is, however, in bronchitic asthma that prophylaxis is particularly imperative. As comparatively few cases of bronchitis originate from direct irritation of the bronchial mucous membrane, but much more commonly from some partial exposure of the skin to unequal degrees of temperature (see *Bronchitis*), so the particular susceptibility of different cutaneous regions should be tested and preventive measures adopted accordingly. As a general rule, in bronchitis which begins usually with a coryza it is the nape of the neck, while in phthisical cases it is the anterior surface of the chest, and in pharyngeal or tonsillar cases the feet, which are the most susceptible to those impressions of passing cold that set up their special tracks of inflammation or hyperæmia in mucous membranes. After a few days' continuance of the catarrhal state, however, the skin of the whole surface partakes in this specific irritability, so that the patients may become aware of a draught from a distant open door which others do not feel. Many cases of bronchitic asthma, therefore, are promptly relieved by putting on a whole suit of buckskin over a light under-flannel, and wearing the same until settled summer weather. These patients also should guard against nocturnal perspiration about the neck and shoulders, by the use of light flannel instead of cotton or linen night-shirts. Daily inunctions with oil also, applied especially to the feet, and preferably done on rising, do much to lessen the tendency to catching cold. The bronchitis itself, of course, should be treated according to its indications, with especial benefit to be hoped for in asthmatics from the emulsion of linseed oil. We need also only allude here to the importance of making the utmost of the intermediate summer period of mitigation

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 deep-seated 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 nerve, 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 anaemia, 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 appear-

ance 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 nerves, 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: \mathcal{R} Kal. iodid., \mathfrak{z} iiss.; Liq. pot. arsen., \mathfrak{z} i.; Spts. eth. sulph. co., \mathfrak{z} iiss.; Tr. belladonnæ, \mathfrak{z} ij.; Spr. aurant. cort. ad \mathfrak{z} 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 vertebrae. 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 dyspnoea. 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 carbolyzed oil—used especially on retiring at night.

William H. Thomson.

ASTIGMATISM* (from α , privative, and $\sigma\tau\iota\gamma\mu\alpha$, 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 imper-

* 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.

fection 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 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

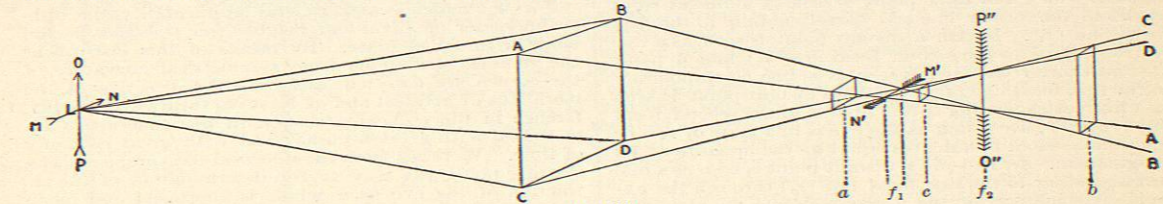


FIG. 366.

measurement of differences in the curvature of the cornea in different meridians and to the study of the refractive phenomena as a whole.

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 Mc.

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.