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Friday, July 7, 1882.

COLONEL LORD ELCHO, A.D.C., M.P., in the Chair.

**“ON CERTAIN CONDITIONS OF SIGHT WHICH AFFECT
ACCURATE SHOOTING.”**

By LITTON FORBES, M.D., F.R.G.S.

The CHAIRMAN: Gentlemen, the lecture about to be given by Dr. Litton Forbes appears to me to be on a subject that has never been treated before, as far as I know, in any lecture, or writing. Dr. Forbes was Surgeon-Major, and served in Turkey in the Servian War, where he had many opportunities of seeing shooting in war. Being a scientific gentleman, he has turned his mind to the effect, as regard shooting, of the construction of the eye in different men, varying as it does in every man more or less. It is especially interesting, because those who are volunteers and all who have been interested in shooting know that a question has been raised that has caused a great deal of feeling one way or another as to whether the orthoptist should be allowed at Wimbledon or not. I was always in favour of its being allowed, and happily this year the restriction upon it has been taken away, and it is to be allowed.

DR. FORBES:—My Lord and Gentlemen,

In considering some conditions of sight which interfere with accurate shooting, I propose to confine myself almost exclusively to certain of those less obvious defects of vision which there is reason to believe are in many cases unknown, and even unsuspected by those who suffer from them. As regards more marked and evident departures from the standard of healthy vision, such as high degrees of short sight, long sight, or pronounced astigmatism, I shall not trouble you with any remarks of my own. This for two reasons. First of all because those whose eyes are thus affected are themselves well aware of the fact, and are as a rule able to discover an appropriate remedy. Secondly, because the subject of defective vision in its more marked forms, as bearing upon the conditions of military life, has been handled in so masterly and exhaustive a manner by Surgeon-General Longmore in his well-known “Manual of Instructions,” that I feel unable to add anything new to what he has already so clearly and ably stated. I shall not therefore say much touching those obvious defects of vision which in civil life as a rule compel a man to wear glasses more or less constantly. I shall confine myself mainly to those, as I believe, no uncommon conditions of sight, in which the eye as an optical instrument is imperfect, indeed, yet not so imperfect but that the routine

work of daily life can be carried out without the adventitious aid of spectacles or other artificial appliances. But however fairly a man may succeed in performing an ordinary day's work without that high standard of vision which the majority of men in this country enjoy, will, I believe, without it, never become a first-class shot. The conditions of vision required for long-range shooting are at the present time very severe. The use of weapons of precision, such as the Martini-Henry and other rifles, make demands on the faculty of sight which the older and less accurate weapons never did. Apart from the fact of the great distances at which good shooting is now made, the mere mechanical conditions required in sighting are themselves an optometric test of the most searching character. It is only necessary to consider the relative positions of the sights on a rifle, in conjunction with the distance of the target, to become aware of this fact. From an optical point of view a target at 600 yards may be said to be at an infinite distance. In other words, rays of light proceeding from it would enter the eye parallel, and would therefore, in a well-formed eye, throw a clearly defined picture of the object on to the retina, a sensitive screen, at the back of the eye, without any effort on the part of that organ itself. The front sight in an Enfield rifle is about 34 inches distant from the back sight, and this latter again is, in the case of an average man, from 20 inches to 10 inches distant from the eye, according to the position adopted in firing. The prone position, which for many reasons appears to be the best for long-range shooting, places the back sight about 10 inches from the eye. The rays of light enter the eye from these three objects, that is from the back sight, the front sight, and the target, at different angles of inclination. The task which the eye therefore has to perform as an optical instrument is to focus these rays of light on the retina, and thereby form the pictures, sharp in outline and distinct in detail. A well-formed eye is perfectly capable of performing this task, as the scoring at the great matches year after year abundantly demonstrates. But an eye in the slightest degree defective will certainly not be able to accomplish it. The test, from a purely optical point of view, is a searching one, such as a one in fact as is demanded of the very best photographic lens. It is well known how a slight imperfection in a lens will mar the resulting picture. It is also known that a comparatively poor lens may be used for certain kinds of photographic work with fair success. It is exactly the same with the eye. An eye possessed of vision quite sufficient for ordinary purposes, and even good enough to satisfy the severest tests of military service in England or any foreign country may, and, I can say from a large practical experience, often do reveal hitherto unsuspected imperfections when tested by the unusual and severe requirements of long-range shooting. These imperfections are of two kinds, viz., either acquired or congenital. In the former case, that is when acquired, they are often progressive. They get worse year after year, until many a man, who has made excellent scoring in the past, is driven practically to abandon match shooting from failing sight, and this at a period when his other powers of body are unimpaired. In the latter case, that is when congenital,

WHICH AFFECT ACCURATE SHOOTING.

existence of such imperfections are very commonly unknown even to their possessors, who fancy that their eyes are as other men's. In fact, however, such is very far from being the case. Their eyes do differ optically, and it is these often slight departures from the standard of absolute perfection of vision which prevents so many from ever becoming good or even fair shots. The symptoms of imperfect vision in slight degrees, when using the rifle, are somewhat as follows: The back sights in aiming appear blurred and hazy, the edges are lacking in sharpness of outline, or perhaps show the colour of the rainbow. Or if the back sights are clear the fore sight is so. When looked at in conjunction with the back sight bar it seems hazy and indistinct. The target may also present either an indistinct or possibly even a distorted outline. At no given instant are the target and fore and back sights sharply and clearly defined when looked at simultaneously, as in taking aim.

The causes of these phenomena are not far to seek. They depend on certain imperfections of the organ of vision, which until lately were not understood even by specialists, and which, notwithstanding all that has been done of recent years, I venture to think have not yet received the full attention they merit. Before examining further into these causes, it may conduce to clearness once more to state the terms of the problem which the eye is called on to solve when sighting a distant target. It is this, viz., "To bring to a focus rays of light proceeding simultaneously from three objects at various distances, one of which is at an infinite distance, and one of the others at a distance of from 10 to 20 inches." Now this is a problem the conditions of which no artificially constructed lens could be made to fulfil. A lens could indeed readily be made to depict on a screen placed behind it, with perfect clearness, the outlines of an object 10 inches off, or at a distance practically infinite. But to do this the screen would either have to be moved backwards or forwards, or the lens itself changed for a stronger or a weaker one, according as it was desired to depict either the nearer or more distant object. Were not done, either one of the two objects when thrown on the screen would be out of focus, that is, would have a blurred outline and hazy appearance. This is exactly what happens in the eye when from any cause the delicate mechanism of sight has become impaired. Either the image of the near object, that is the back sight of the rifle, or the image of the distant object, that is the target, is blurred and indistinct. They are not simultaneously clearly defined and sharply outlined.

The power by which the human eye is able to see with equal distinctness an object at an infinite distance and an object close at hand is known as the power of "accommodation." This power resides in the lens of the eye. It may briefly and with sufficient accuracy be said to consist in a change of shape of the lens itself. In early life this inherent power exists to a much greater degree than at or after middle age. Indeed, according to the researches of Professor Donders of Utrecht, it is continually failing from infancy to old age. Its failure is, however, perfectly regular and constant, and is in no sense a disease. It is a physiological change in the eye itself, analogous

the advent of grey hair or wrinkles, as age approaches, in the generally. The ratio of this failure is well known. An object at four years of age can be clearly seen at say 3 inches, at the age of five cannot be seen much closer than at about 8 inches. The near distinct vision has in fact receded just so much. The least distance which an object can be clearly seen continues to diminish up to most advanced age, until finally it may be said to have completely to exist. At the age of seventy-five the nearest point of distinct vision is about 2 feet in front of the eye; in other words, under no circumstances, nor with any effort of its own, can the eye see a small object distinctly within this distance. The practical bearing of this on rifle shooting is abundantly evident. In a series of measurements which I have recently taken, I find that in men of average stature the length of arm, the back sight is, in the prone position, distant 10 inches from the eye; in other positions about 20 inches. It is evident, therefore, that a man, say of the age of forty-five, who is constantly increasing far sight, would at 10 inches be unable to see clearly the back sights. He could do so with more success at 20 inches. Even at this distance, however, he would not be perfectly at hand for as his near point recedes, so also does the effort necessary to bring it nearer to the eye become greater. The eye, therefore, if the aiming was at all prolonged, might fairly be expected to exhibit signs of fatigue. This, as a matter of observation, it often does, as shown either a sense of uneasiness in the organ itself, or a sudden loss of distinctness in the objects looked at. Moreover, inasmuch as the harmony of the component parts of the eye are disturbed, more especially of what is known as chromatic aberration is developed, that the edges of the back sight are not merely blurred, but also color fringes of condition extremely opposed to accurate aiming. In such a case the mere position in which the rifle was held might influence the vision very considerably by rendering the conditions of aiming more difficult. This condition of impaired vision is known as presbyopia or "old sight." In civil life it is easily and effectively corrected by the use of suitable convex glasses for reading or other near work. In rifle shooting, however, this is not possible, for the correcting glasses which would make the back sight clear, would at the same time blur the front sight, and still more the target itself, blurred and indistinct. To correct this condition of vision we are therefore obliged to have recourse to another method, which I shall describe later on.

But although the existence of slight degrees of "old sight" is a serious hindrance to accurate shooting, it is, when it occurs, by no means absolutely incompatible with it. If unaccompanied by other imperfections, it is not only capable of alleviation, but is never present at an age when a man's shooting powers are at their best. Unfortunately, however, it is very frequently associated with another condition of vision, known scientifically as hypermetropia, or "long sight." This condition is the exact opposite of short sight, or myopia. Unlike old sight, or presbyopia, it depends not on any change gradually taking place within the eye, but on a faulty shape of the eye-ball itself. In a well formed

rays of light coming from the horizon are brought to a focus on the sensitive screen or retina, without any effort on the part of the eye itself. But in the long-sighted, or hypermetropic eye, such is not the case. The focus for parallel rays falls beyond the limits of the eyeball, or, in other words, they are never brought to a focus at all unless an effort is made by the eye itself. Now this effort can only be made at the expense of the accommodation, and, consequently, a certain portion of the available power of accommodation is, so to say, wasted in the endeavour to gain a distinct view of distant objects. But, as already stated, the advent of "old sight" depends on the failure of accommodation. If, therefore, a certain proportion of all the available accommodation be required in order to neutralize a certain defect in the form of the eyeball itself, it is evident that a less amount will remain to correct or compensate for those changes which age, in the natural course of things, produces in the structure within the eye itself. In this way can be explained the apparent advent of "old sight" in young men. It is only within very recent times that this condition has been understood, and its great practical importance recognized. A glance at the diagram on the wall will show that the hypermetropic eye is essentially a short eye from before backward. It is, as it were, an undeveloped eye, in contradistinction to the short-sighted eye, which might be called over-developed. I have met with this condition of sight most frequently among recruits from rural districts, though it is also common enough among dwellers in cities. This defective form of eyeball is born with a man, and therefore cannot be directly remedied. When it exists in high degrees it frequently causes squint, or shows itself in other obvious ways. It is a common cause of so-called "weak sight" in early life, of headaches, of a sense of weight in the eyeball and eyelids, and of other unpleasant symptoms. We are now, however, chiefly concerned with it when it exists in slight degrees. It is then often masked by the excessive power of accommodation which the eye possesses in early life. It does not perhaps, show itself until either the work of education, with its consequent strain on the eyes, has commenced, or until some crucial test such as that afforded by sighting a target at long ranges, is applied. When a hypermetropic eye is called on to satisfy such a test if the amount of hypermetropia present be not large, and especially if the power of accommodation be still strong, it may not immediately fail. The optical conditions required for aiming with one eye are not quite so difficult to satisfy as is the condition of reading at short distance with both. But long before the accommodation would fail in the ordinary eye, it will have failed in the hypermetropic. Owing to the being less available accommodation, old sight, with all its attendant disadvantages, will have set in. Moreover there can be little doubt that the mere act of accommodation, when required for viewing distant objects, impairs that perfect harmony between the various factors of the dioptic system necessary to perfect vision. This impairment may be expected to show itself in a want of distinctness in the front and back sights. The target will probably, in a young hypermetrope with good accommodation, appear distinct enough, but the edges of the

back sight and bar will be blurred and fringed with colours. Hypermetropia depends essentially on the fact that the eyeball itself is too short for the dioptic system which it contains, it is evident that in proportion to the amount of shortening present, so will be the amount of hypermetropia. High degrees are easily detected by an one familiar with such cases. It is not so, however, with low degrees which I have every reason to believe exist much more frequently than is generally supposed. These require peculiar methods of examination for their detection, combined with a certain amount of time and trouble. I am persuaded, however, that it is well worth while for any man who aspires at being a good shot, and who feels that his sight is not quite what it should be, to undergo an examination for latent hypermetropia as a necessary preliminary. Such an examination may save an immense amount of useless practice, of loss of time, and of consequent disappointment. This examination is all the more advisable because the condition known as hypermetropia is easily corrected by suitable glasses. The imperfection of vision is here not due to the same cause as in "old sight." There the employment of a lens to improve vision was impossible, because the lens would necessarily render distant vision indistinct. In hypermetropia a suitable lens increases the refractive power of the eye, and makes sight as acute as it would have been had the eyeball been of the normal length. By the use of glasses distant objects can be clearly depicted upon the retina without an undue effort on the part of the eye itself, while the power of accommodation is preserved intact for the purpose it was primarily intended to serve. The important fact about hypermetropia, so far as accurate shooting is concerned, is that it may be present in very slight degrees, so slight indeed as to be wholly overlooked, and yet that it may be sufficient to interfere very disastrously with accurate aim and large scoring.

I now pass on to consider the opposite condition of hypermetropia that is myopia, or as it is popularly termed "short sight." In this case the eyeball instead of being too short is too long. In other words its axial length is less than its focal length. Parallel rays of light are, therefore, not brought to a focus actually on the retina, at a greater or less distance in front of it. The resulting image is consequently blurred and indistinct. This is the case especially with distant objects. By no unaided effort of the short-sighted eye, distant objects are seen distinctly. Near objects on the other hand are seen much closer than in the case of the normally constituted eye. In the hypermetropic eye the amount of hypermetropia is measured by the amount of accommodation required to see clearly the distant horizon. In the short-sighted eye we are concerned chiefly with the fact that the accommodation is often practically in abeyance, and that while within certain limits near objects will always be visible, distant objects will always be hopelessly blurred and indistinct. Short sight has nothing to do with the position of the near point. Its degree is determined solely by the farthest boundary of vision. The short-sighted eye cannot see the horizon or a distant target clearly, but within certain limits, within these distances, it can see objects q

distinctly. Of all imperfections of sight existing among large bodies of men short-sightedness is the most frequently met with. This is particularly the case among recruits from urban districts, for causes to be mentioned later on. In the class of conscripts in France for the year 1878,¹ Dr. Nicati states that out of 3,357 total rejections for bad sight from one cause or another, myopia accounted for 511. In 1879 it accounted for 378 out of a total of 3,468. To understand the full significance of these figures, we must bear in mind that according to the statements of French authors themselves the standard of vision in the French army is exceptionally low. Thus, while Germany requires from her recruits for general service an amount of vision not less than half the normal amount, and while England requires somewhat less than Germany, France is satisfied with a quarter. Now these high degrees of myopia are comparatively rare. The lower degrees are far more frequent relatively. For one man who possesses, say, one-tenth of myopia, there will be at least half a dozen who will possess amount less than this, say from one-twelfth to one-sixtieth, seventieth, eightieth, or even still less degrees. In civil life, under many circumstances, a low degree of short-sightedness is not a very great disadvantage. If a man can see clearly objects within, say, six feet, would, by many, be considered scarcely short-sighted at all. It would simply have a more or less hazy horizon, a condition readily enough corrected by an eyeglass. These low degrees of short sight are, I have reason to believe, much more common than is generally supposed. Theoretically we might expect to meet them frequently because short sight depends on a slight elongation of the eye itself. Now, in the conditions and surroundings of civilized life there are many circumstances which predispose to this lengthening. A very slight amount of disproportion between the focal length and the axial length of the eye will produce a considerable deterioration of vision. Thus, a lengthening of only one-eightieth of an inch will, according to a calculation I have made, about one-fortieth of short-sightedness.

Now it is exactly with these very low degrees of short-sightedness that we are most concerned. The conditions of rifle-shooting are in many respects different from those of other arms, just as the conditions of a volunteer battalion differs in many respects from that of a line battalion. While no country would exclude a recruit because he possessed a fortieth of myopia, we shall see that this amount if uncorrected would almost incapacitate for long range shooting. By the expression I do not mean altogether shooting at a target at a distance off. I mean rather that faculty of quick and accurate judgment which enables a man to judge distance correctly and to fire quickly, which enables him to take in a glance the salient features of distant objects, and the characters of a country or landscape, and, moreover, enables him with the quickness of thought to distinguish the arms and estimate the force of any hostile body he may chance to encounter within the extreme range of his rifle. Now it is in

¹ "Archives d'Ophthalmologie," Mars—Avril 1882.

ing and instructive to consider for a moment the actual effect on the sight for distance, of these low and almost unnoticed degrees of myopia. Dr. Girard Teulon, of Paris, from a series of experiments concluded that a physiologically acute eye which was myopic one thirty-sixth, lost thereby about half its faculty of vision. Prof. Noël, of Louvain, perhaps a more accurate authority in this matter states that acuity of vision useful for distant objects varies between two-thirds and two-fifths for a myopia inferior to one forty-second is below one-fourth from one-thirtieth to one-twentieth, which are limits accepted in recruits in this country, for a myopia of one-sixth to one-fifth, such as is allowed in the French and Italian arm. Distant vision is only one-thirtieth of what it should be. But English soldiers are not allowed to wear glasses, and perhaps rightly still it is impossible to help inquiring what sort of shooting a man in active service would be likely to make with an arm of the Mart Henry type, when possessed only of one-fourth of normal vision. "Such a man at the distance of fifty yards and upwards groups of four or six persons standing together before a dark background cannot be counted with accuracy. More distant objects such as the general features of a landscape are huddled together, and become little more than shadows with indeterminate outlines. The nature of particular objects of large size can only be made out when the accidental advantage of some sharp contrast is afforded, such as is presented by a boat floating on water, by a building or a tree having the sky as a background, or when a well-known object, such as a horse, is in motion on a road. Even this last object ceases to be distinguishable at a distance of seven or eight hundred yards, if it be passing by a dark background such as a belt of trees."¹ But there is still another disadvantage to which the short-sighted man is subject, which is that as the light fails his vision fails much more quickly than does that of an individual with normal sight. This depends on the fact that the proportion as the pupil dilates, so the circles of diffusion increase on the retina. Even very low degrees of myopia become, therefore, a great disadvantage in the use of the rifle towards evening, or in fog and cloudy weather.

The existence of low degrees of short sight does not, as is popularly supposed, preclude the presence of "old sight." In old sight the point of distinct vision has receded beyond ten inches. If a man is therefore short-sighted only beyond, say, forty inches, it is clear that he may be presbyopic for near, and myopic for distant objects. The simultaneous existence of two distinct conditions of impaired vision, as is, I have found by experience, far from uncommon. It is a condition, however, very frequently overlooked, and is a source of great annoyance and perplexity to the person who is the victim of it. In such a case vision both for near and distant objects is blurred and indistinct. Moreover, the power of accommodation in a myopic eye is very often through want of use, weaker than it should be. Consequently, in persons with presbyopia may come on earlier than in properly formed

¹ Longmore, "Manual of Instructions," p. 77.

A man of, say, fifty years of age, with one-fortieth of short sight would not be able to see the target clearly nor the front sight, because they would be beyond the limit of distinct vision, which in his case is forty inches. But inasmuch as his near point of distinct sight has also receded beyond ten inches, he could not in the prone position firing see the back-sight. Yet such a condition of sight might easily escape notice in civil life. Many persons indeed would be satisfied with the use of a weak convex glass, which would enable small print to be read at the distance of about a foot. In rifle practice, however, such a glass would be inadmissible, because, although it might render the back sight clear enough, it would hopelessly blur the front sight and target. The addition of a convex glass of one-fortieth would exactly double the myopia, changing it from one-fortieth to one-twentieth, or according to Professor Noël's calculation, reducing the acuity of distant vision to one-fourth what it should be. A combination therefore of "old sight" with low degrees of short sight seems a most hopeless condition of vision so far as rifle shooting concerned.

In cases where the power of accommodation is still good, that where "old sight" has not yet supervened, I cannot myself believe that the existence of low degrees of myopia should necessarily be fatal to good shooting. Of course the existence of any myopia will blur more or less the horizon and all distant objects, and possibly even the front sights. The back sight also will not be quite clear because, although theoretically, it does not lie beyond the range of distinct vision, yet practically, owing to the optical conditions of the eye, its image will be thrown on the retina in an ill-defined and imperfect manner. The edges will be blurred, and more or less iridescence and correctness of aim will thereby be very much interfered with. In these cases the proper correcting glasses should be worn constantly, not only while firing, but at distance-judging drill, and generally whenever a man has a rifle in his hand. Short sight is not a disadvantage. It is simply an optical condition of the eye, which in low degrees is completely under control. When present in a limited degree it can be completely corrected by glasses, and sight can be rendered for all practical purposes perfect. I must protest, however, in these cases against the occasional and fitful use of glasses, and certainly against their use in general. A man with a slight degree of myopia, who wishes to be a good shot, must have suitable spectacles which accurately correct, and no more, his short sight. These he must wear constantly, in order to get accustomed to the appearances of objects at varying distances. An occasional use of glasses is, I believe, worse than not using them at all. Let the marksman, therefore, either choose to shoot with or without them, if indeed this latter alternative is possible. To wear them occasionally at the firing point, at matches only, may possibly help the score. Such a course will, however, most certainly prevent a man from acquiring that perfect mastery of his weapon, which it should be the object of everyone to attain who takes a rifle in hand.

There is also another point of view from which this subject of s

sightedness assumes great interest and importance. I have already referred to the fact that by many oculists the hypermetropic eye is considered an undeveloped form of eye. Conversely the short-sighted eye may be considered an over-developed eye. Certain it is that much of the ordinary work of civilized life tends directly to the production of this over-development, or, in other words, of short sight. This fact has been brought out very clearly by the researches and observations of Dr. Cohn in Breslau, Drs. Agnew and Loring in New York, and Dr. Erismann in Russia. Dr. Cohn, with Teutonic patience, examined the eyes of 10,060 children, among whom he found that 1,004 were short-sighted. But what was more important, he found also that short-sightedness increased steadily both in the relative number of cases, and in degree as he ascended from the elementary to the higher classes. Dr. Loring, of New York, carried out a similar series of observations on the students of one of the largest universities in the United States, during the graduation period of four years. He found that, in a given number of individuals, each successive year of study added to the number of short-sighted persons, or increased the degree of the defect where it already existed. Now, the whole tendency of modern life is in the direction of those employments which are calculated either to produce myopia, or to aggravate it if already existing. Education is now carried on at high pressure, without much regard either to the eyes or the bodily health of the disciples. Children begin to study earlier and continue at their books to a much longer age than they did a generation ago. There is an increasing dislike of occupations requiring manual labour, and a corresponding desire for those entailing head work only. Nor is this condition of things likely to be materially altered in the course of succeeding generations. On the contrary, as the struggle for existence becomes intensified, and the process of centralization which is so marked a characteristic of modern age becomes more developed, so may we expect to find that the number of those employed as clerks and penmen, or at sedentary occupations generally, will increase relatively faster than the population itself. Reason and analogy both go to show that one direct result of all this will be a very considerable increase of short-sightedness among those classes which in England at least have heretofore enjoyed a comparative immunity from it. As a rule volunteer corps are chiefly recruited from these very classes, and therefore the existence of any great increase of short-sightedness among them is a matter for serious consideration. Much can be done in the way of prevention, and much also in the way of cure. But I am of opinion that the first symptoms of the advent of short sight should be carefully looked for in young recruits, and when detected should be at once treated by suitable glasses. These should be worn as a matter of course on all occasions when the rifle is handled, and more especially at distance-judgment drill and target practice. The education of the eye will thus be invaluable for practical purposes, and in this way, and in no other way only, can a short-sighted man ever be made into a good or useful marksman.

I now pass on to the consideration of another condition of v

which interferes very considerably with accurate shooting. I refer what is known as astigmatism. This condition may be described one in which the curvature of the front of the eye is different in horizontal direction from what it is in the vertical. Probably this is the case in most eyes, and it is only when the difference of curvature is more or less considerable that the resulting astigmatism becomes a source of annoyance. Such a difference of curvature may cause an eye to be at one and the same moment far-sighted or short-sighted, according as vertical or horizontal lines are looked at. Or, again, the same eye may be wholly short-sighted or wholly sighted; but these conditions may exist in different degrees, according to the position of the objects looked at. Thus, it would be possible with such a condition of vision for certain portions of distant objects to appear perfectly distinct, while certain other portions, placed, say, at right angles to these, would be hopelessly blurred and ill-defined. Such a condition of sight, therefore, not only renders near and far objects indistinct, but also to a very appreciable extent distorts their outlines. An astigmatic person can, in fact, see neither at a distance nor near, nor is this condition sensibly improved by spherical glasses, such as are ordinarily used for spectacles. The detection and estimation of astigmatism is often a proceeding of some delicacy and difficulty. It requires special appliances, and certain forms, indeed, that is in the so-called irregular astigmatism does not admit of accurate correction. Astigmatism may be present with both far sight and short sight, and, indeed, seldom occurs in practice without one or other of these complications. To detect and correct it satisfactorily it is often necessary to paralyse for a time this activity of the accommodation by means of atropine. In this way the exact amount of astigmatism can be found, and as it neither increases nor diminishes with age, it can be corrected once for all either by the proper cylindrical glass, or by the union of a cylindrical and spherical lens.

The influence of even low degrees of astigmatism upon the sight is very marked, and is exerted in various ways. Its first and most obvious effect is to produce differences in the apparent distinctness of lines, drawn in different directions. In this way astigmatism produces indistinctness of some of the linear boundaries of figures, while others are clearly defined. The indistinctness of many boundary lines produces a corresponding diminution in the acuity of vision, and the necessity of constantly altering the adjustment of the eye, looking at different parts of the same object, produces great fatigue of the accommodation. Hence, astigmatic persons complain merely of defective sight, but also of weariness and aching eyes. These symptoms are sometimes kept in abeyance so long as the accommodation is strong. But in proportion as this latter fails with advancing years, so does the astigmatism tend to increase, and the eye becomes more irksome.

As regards the effect of this condition of vision on accurate shooting I need not say much. To the astigmatic man, as to the myopic man, the sights of a rifle will be blurred, while neither sights nor

will appear in their actual and proper shape. Indeed the relative distortion which objects undergo is the distinguishing characteristic of this condition of impaired vision. Its effects are most felt in judging distance, and in shooting at long ranges. As already remarked, admits of correction by suitable glasses. These glasses, as I have already ventured to say in respect to myopia, should always be worn whenever the rifle is taken in hand. If only worn at matches they may indeed on occasions help the score, but they will not really confer any power of superior shooting under conditions which would scarcely arise in active service. An eye thoroughly trained to judge distances, and to study the features of a landscape through glasses will be nearly, if not quite, as quick and accurate as one which is fortunately independent of such adventitious aid. The important point is that the training should be continuous, unintermittent, and thorough. In other words, a person whose vision requires glasses raised to the normal standard should never attempt to shoot without such glasses, for by so doing he will not only fail to shoot well, but will moreover deprive himself of a great portion of those benefits which glasses would undoubtedly confer upon him.

I have now considered the four chief conditions of vision which whether occurring in low or in high degrees, may be said to interfere seriously with accurate shooting. There are, of course, other possible conditions of impaired vision, such as commencing cataract, asthenopia, deep-seated changes in the eye itself, or a want of harmony between the optical conditions of the two eyes, which would also very materially affect the use of the rifle. These, however, may fairly be omitted, either because they tend to cure themselves, or else because they admit of no cure whatever, and, therefore, render rifle shooting simply impossible. The conditions which I have considered in detail in this paper admit, on the contrary, of almost complete correction detected early, if not too high in degree, and if properly treated, and are not, I believe, incompatible with a very high degree of excellence not only in target or match shooting, but also in those other varied and more difficult services which a body of trained rifle men might be called on to perform in actual warfare.

In considering how best to deal with the conditions of impaired sight which I have enumerated, it may be well to say a few words to what has been already done in the same direction. The blurring of the back sights has long been a matter of complaint with good marksmen who are perhaps no longer young, and who find, as might be expected, that with failing sight their power of making large scores is failing. The cure of this condition is, within certain limits, not difficult. The blur may be removed by the simple device of looking through a pinhole aperture. Or, were this not permitted, it might also probably be removed for a time by the instillation of a few drops of some agent which would contract the pupil to the size of a pin and would thereby, on well-known optical principles, render the retinal images much more distinct and perfect. Such an agent is perfectly well known to oculists, and it would certainly, I think, be worth a trial by any person whose only object was to make a

score on a given occasion. The stenopæic or pinhole-opening, which is really an artificial pupil smaller than the natural one, will improve myopic, hypermetropic, or astigmatic vision for the time being. It does so in these various conditions by acting in different ways which I need not now dwell on. There is, however, to my mind, no fatal objections to the use of these perforated discs. The first is that they simply palliate or alleviate the impairment of vision without attempting to remove its cause or causes. The second is that it entirely destroys the field of vision, and limits sight to the single object which for the moment happens to be directly before the eye. This renders impossible, therefore, any accurate perception of surrounding objects, or any nice comparison between the several parts of objects which, as every one knows, is essential to the formation of a correct estimate of distance. No one, so far as I am aware, has proposed that any company should learn their drill armed with this appliance. Even although it should for the moment improve vision, it would do so at the sacrifice of what I take to be more valuable than even a central vision, viz., uninterrupted vision over a large extent of country.

In considering how this difficulty might be met, and how the accuracy of vision might be improved, while at the same time the range of vision in all directions was not lessened, I have kept two objects in view. One is to correct, that is remove the actual optical condition which is the cause of the impairment of vision. The other is to provide an appliance such as may be worn at all times and under all circumstances, from the very day on which the recruit commences to learn his drill. The first of these indications is fulfilled by the use of glasses which will exactly correct the faulty condition of the eye itself. The sight should first of all be carefully tested, and the nature and degree of the impairment of vision be accurately measured. This will in many cases be sufficient, and if the glasses thus found be constantly worn, nothing more will be needed. The principle of the pinhole aperture is, however, an excellent one, and should, if possible, be served. In order to do this, without at the same time unduly limiting the field of vision, I replace the metal disc by a disc of coloured glass, perforated with a stenopæic aperture. This aperture admits white light, whilst the remainder of the glass allows only coloured rays to pass through. The resulting contrast, by a well-known optical law, serves the purpose of an opaque disc, without, like it, completely abolishing all but central perception. Having thus corrected the error of refraction, to which the impairment of vision is essentially due, by a suitable glass, and having also, by means of the coloured ground, secured the main advantage without the drawbacks of the stenopæic disc, it remains only to provide, if possible, in one appliance this double gain. This might be effected in very low degrees of short or long sight by having a coloured ground to the proper focal length, and then perforated with a conical aperture. But a practical difficulty exists in the way of doing this, owing to the fact that coloured glass, when ground into the form of a lens, becomes lighter in tint the thinner the glass is.

This difficulty has been met by using a coloured glass of uniform thickness, to the back of which the correcting glass, which must be either a plano-concave or convex lens, is fastened. In this way it is believed the double advantages of glasses and of the stenopæic aperture can be obtained simultaneously with a minimum of disadvantage. The instrument corrects at once any anomaly of refraction present, and, at the same time, while rendering central vision more acute, does not curtail the field. In simple cases of presbyopia the mere aperture, without any correcting lens behind it, will probably be sufficient. In certain forms of astigmatism a cylindrical lens placed in front of the coloured disc might occasionally be necessary; but the addition of this need offer no practical difficulty. Some little practice with this instrument will be necessary before its advantages become fully apparent. The instrument, which perhaps I may be permitted to call "the stenopæic sight adjuster," may be worn either suspended before one eye from the back of the cap, or in a spectacle frame. The latter method is preferable, because the small aperture can thereby be kept more steadily in front of the pupil, and also because the optical centre of the correcting lens, united with the coloured disc, will thus be kept directly in the line of sight. To fulfil this indication more fully the spectacle frame should curl backwards round the ears, by which means a firmer hold and greater steadiness can be obtained. As regards the other eye even though not employed for aiming, it should nevertheless be provided with a proper correcting glass, that is it should suffer from any optical imperfection which impairs its acuity of vision for distant objects. In the case of simple uncomplicated presbyopia this will not be the case, and therefore a disc, such as I recommend, used before the right eye, would probably be sufficient. In most cases, however, presbyopia is complicated with low or varying degrees of hypermetropia, myopia, or astigmatism, as already explained. In such a condition requires not merely a stenopæic opening, but also a correcting lens behind it, in order to restore the imperfectly formed eye to the same optical condition as a normal eye.

It will be observed that before this instrument can be used the "refraction" or optical condition of the eye must be tested, and a correcting lens made accordingly. Once the proper glass, which corrects the optical error, has thus been found, I hold that that glass should constantly be worn on all occasions when the rifle is in use, whether for purposes of firing or of mere drill. Spectacles, if worn occasionally, are, so far as concerns the practical training of a man, rather a snare and a delusion than a help. If, however, they are worn constantly, the eye becomes accustomed to their use. It is to be noted that to note accurately and readily the delicate play of light and shadow and the changes produced in the forms of objects at varying distances. If, however, along with this, central acuity of vision can be increased while its lateral range is not destroyed or even impaired, the advantage would be still greater. Whether I have succeeded in accomplishing this object, the practical test of experience can alone show. It is while the great importance of the subject of slight imperfect vision in regard to the use of the rifle, in every branch of the service

must be my excuse for having ventured to bring this paper before the Royal United Service Institution.

The CHAIRMAN: Now, gentlemen, if any person present who has turned his mind to this subject will offer any remarks, I have no doubt everybody will be glad to hear them; or if any gentleman wishes to ask any questions with reference to this very interesting paper, I have no doubt Dr. Forbes will be willing to give an explanation that may be required.

Mr. CURTIS: My object in addressing you, my lord, is simply to take a slight objection to one statement made by the learned doctor. He speaks of the orthopticon entirely destroying the field of vision. Now, if anybody looks through an orthopticon disc he will have at a distance of 600 yards a field of vision 200 yards wide. He is one, if any gentleman likes to look through it; and standing at six feet from the wall, I will guarantee that he shall see two feet spaces at least. I cannot help thinking that it is that idea that made the Association object to it for fear it might endanger the lives of the markers.

Mr. GEORGE BAKER: I should like to ask the doctor if he has ever got a hole sufficiently clean to give a clear margin. That is always the difficult thing in trying to drill a hole or aperture in glass—to get it sufficiently clear, but it is essentially necessary that any aperture in a disc should be clean cut. We have tried a great number, and we have never succeeded at all effectually.

Mr. CURTIS: I tried your system some years ago. The disadvantage of it is that it admits light to the aperture sideways. I have one here in my pocket with a really clean cut conical aperture that I made a long time ago, but could never use it for shooting purposes.

The CHAIRMAN: A glass with a hole in it?

Mr. CURTIS: Yes; you can compare it with Dr. Forbes'. It is simply a glass with an aperture in the centre. One eye of these spectacles is fitted with "orthoptic," and the other with a "stenopæic" for comparison. The disadvantage of the latter is seen more out in the sunlight.

Captain BEDFORD PIM, R.N.: I should like to thank Dr. Forbes for his interesting paper. I for one am very much obliged to him, because my son, who is in the "Devil's Own" Regiment of Volunteers—a most distinguished regiment—has been trying for a long time to become a good marksman. Now when I had the honour of being leading file in Company A in that regiment, I was a good marksman, and got a marksman's mark, but my son cannot manage it. I see the Doctor makes a suggestion that an examination should be made. I think that a capital suggestion, and I shall take care at once that my son is examined by a known oculist, to see whether he had better persevere, or whether there is an optical delusion in his eye. His cousin, Sir Charles Locock, is the great marksman of the Devil's Own, and he has been encouraging my son to come down and practise, but he cannot manage to make much progress, though he perseveres day after day. I should have liked Dr. Forbes to have gone a little into the question of signals at sea—signals with regard to different colours at sea. We have the most extraordinary evidence in the Law Courts with regard to colours. This very day I have been in the Court, and a man swore positively that for 15 minutes in the case of the "Douro," when the ships were going at 10 knots an hour, he had seen the green light of the Spanish ship. Now it is quite impossible to see a green light at any circumstances of weather, no matter how good they may be, for more than 2½ miles, yet he swore positively that he had seen that green light, which must have been at the very least, supposing his time was correct (15 minutes), 5 miles off. I find Dr. Forbes has not alluded to that. He appears not to have alluded to it at all, but the subject is of such great importance to the Army and Navy Reserve Forces, and all armed forces, that I believe he will forgive me for giving him a hint to turn his attention to that very important subject. It would be of great use to sailors, for the imperfect vision of the look-out man has caused many and many a collision, and the loss of hundreds if not thousands of lives. I for one most cordially thank Dr. Forbes for his very able paper.

General BLUNDELL: I merely wish to ask whether fog does not prevent glass assisting short sight.

Mr. RAGLAN THOMAS: As a member of the medical profession, and also a rifle shot, I have taken very great interest in the lecture, and beg to join in the expression of thanks to the lecturer. I trust he will excuse me for having been a few minutes late. Possibly one of the questions I am going to ask may have been answered in the first five minutes. I wish to ask whether he does not consider that the back-sight of the Snider rifle is too near the eye. Last year, upon the abolition of the back position, I never found any difficulty at all in vision; at all ranges I was able to do a steady score, but since the back position has been abolished, I have found great difficulty in shooting, especially with the Snider rifle. During the earlier part of the season I shot entirely with the Snider because I had no Martini ammunition. I found that with the Snider rifle I could scarcely shoot at all, but with the Martini I certainly found it different. I find I can generally see fairly, almost as well as I could on the back, but the power of vision fails slightly at the long ranges, especially at 600 yards there arises a slight blur, and I think my vision must be slightly hypermetropic. I have also tried the orthoptic, and find that with the smallest and the smallest hole—there are generally three holes drilled—there is a film in the centre of the aperture, but not so much so in the larger hole. I shall take an early opportunity of consulting one of my professional brethren, who has given great attention to the subject of eyes.

Dr. LITTON FORBES: As regards the orthoptic destroying the field of vision, course that statement must be taken in conjunction with the context. I consider it limits and practically destroys the field of vision for purposes of drill, and would interfere in general warfare with details of great importance, such as judging distance, and so forth. The sole end and aim of the Volunteer organization of the country is not merely to shoot at targets, and I do not believe it would in practice be possible to drill or utilize in the field any company of men wearing orthoptics. Looking at the instrument from a purely optical point of view, when you place the orthoptic in front of the eye, you cause the rays of light to enter that eye readily, in accordance with the mathematical laws which underlie physiological optics, and thereby you do away with the source of the inherent imperfection of the organ of vision, but you lessen at the same time the range of the ocular movement and the range of vision. Looking through a pin-hole, you can see an immense range of country on either side, but attempt to use the orthoptic in the various details of judging distance, of examining a landscape, &c., and you will at once think, find it impossible to do so successfully. As regards Mr. Baker's statement about the difficulty of drilling holes in glass without chipping, I must say I did not find that a practical difficulty. In laying these models before the Royal United Service Institution, I do not wish to lay claim to any particular novelty or success. I had hoped to elicit from the members who have had more practical experience than I, as to whether anything could be done in the direction of keeping the advantages of a stenopæic hole, while at the same time, by utilizing the "high contrast," of keeping also some of the advantages of the free movement of the eye, and with it the power of taking in rapidly large stretches of country: in other words, of judging distance. I think what I have said will answer another question. I have made a good many experiments, but at present I am only working tentatively, and the reason I have brought this paper before the Society just now is the near approach of the Wimbledon meeting. If I had had plenty of time probably I should not have volunteered to place anything before you to-day, but do hope that somebody following on the same lines will hit on a thoroughly practical instrument. However, I think I may claim some originality in wishing to put the orthoptic lens behind the coloured disc of glass. In that way the advantages to be derived from the use of coloured glass may be secured, advantages which would be lost if you attempted to grind a lens out of coloured glass only. The stenopæic hole secures some of the advantages of contrast, but there may be a practical difficulty as regards the edges of that hole. However, I have been assured by a well-known optician in London that it is possible to drill a hole in glass without chipping the edges. Captain Bedford Pim was kind enough to make some remarks which I am sure

WHICH AFFECT ACCURATE SHOOTING.

very pleasing, but I fear too flattering to myself. I should like to say that I seen a good deal of sea-service, and have devoted some attention to what he alluded to. The subject of coloured lights is a very large and important one. I believe that a vast number of men who are put on watch at night are not in a condition, so far as their eyesight is concerned, to go on watch. I last year in London examined with others over 8,000 cases for colour blindness, and an average of 3 to 4 per cent. of impaired colour vision was found, with from 1 to 2 per cent. complete colour blindness. It is of course easy to calculate from the above how many out of, say, 10,000 men taken at random will probably have more or less colour blindness. As to seeing the green light at sea at unusual distances, it seems to me that the fact Captain Bedford Pim refers to may be explained in this way. It is well known that many persons who are colour-blind can yet learn to distinguish the colour of a light simply because the amount of illuminating power given out by various coloured rays differs. Hence, although to two persons a green light and a red light seem equally colourless, yet one may see it more clearly and therefore distinguish it from the other. In this way may be explained the fact that engine drivers with impaired colour vision are able to avoid accidents. They cannot see the colours, but they can distinguish the difference in the amount of light given forth by the red and green lights respectively. If, therefore, the witness mentioned by Captain Bedford Pim swore that he saw a green light seven miles off (which of course seems impossible) it could only have been that he recognized the light by some rule of his own which he had hitherto been accustomed to do so, and it is conceivable to me that a green light to a colour-blind man would at seven miles give at any rate a certain amount of distinction from a light of any other colour. As regards General Blandell's question, the optical effect of fog is, if anything, to shut out a certain amount of light. It has no bearing on the question of refraction proper. In other words, myopia or hypermetropic persons in clear weather or in foggy would be influenced by the regular laws governing vision, but inasmuch as the near-sighted eye failing light tends to form circles of diffusion on its retina, the fog would probably interfere more with short-sighted than with long or normal sighted persons, because their pupils would dilate, and the diffusion circles therefore would be greater. As regards Dr. Thomas's statements about the Snider rifle and the back position, that he can shoot better with the Martini than the Snider, the first part of the question induces me to believe that there is present in his case hypermetropia, or more or less loss of accommodation, and no doubt as years go on matters with him will get worse; but the latter part of his statement, viz., that he saw what appeared like a film, is distinctly a characteristic of astigmatism. A very good example of astigmatism may be obtained by holding the finger and thumb close together and looking through the interval between them. Anyone who does so will see, appreciably, before the thumb touches the finger, the formation of a sort of drop. This can be got over by looking through a pin-hole opening, when the actual contact of the finger and thumb will be seen perfectly clear. I should make a rough diagnosis of his, Dr. Thomas's case, and say that there was a certain amount of hypermetropia complicated with astigmatism present; and also I should venture to add that the nearer the back sight was held to the eye, the more indistinct it would become, the more difficulty he would find in aligning the target. A case of that sort should say, would require a good deal of examination, and possibly there might be a question of the amount of accommodation present, and whether it was in excess or deficiency.

Mr. BAKER: I should like to offer one more remark in favour of the orthoptical which is that I think it is analogous to a telescope where you have a series of lenses. You may take your eye as the eye-lens of the telescope, the fore sight as the object-glass, and the back sight the erector. Now, if you have more than one lens, and have no stop, no matter how well the lens may be ground, you will always get a great deal of distortion; but place a stop in at the proper point and everything is clear and well defined. I think that the orthoptical just meets the case exactly and so gives you that accommodation that the eye has not naturally, and enables you to define all clearly at one time.

Dr. FORBES: The stop which nature has provided is the iris; the coloured part of the eye acts as a stop. If we interfere with that and put another stop on the

of it, we must more or less mar the function of vision. Besides, considered from scientific point of view, the orthoptic is really another sight, because, although you look through the orthoptic at the back sight, you really do away with back sight altogether. You also reduce the eye from a living organ of vision to the position of a mere mathematical or geometrical *camera obscura*. You allow a pencil of light to enter instead of the full rays of the sun. Of course, if you only admit a pencil of light, you bring the mathematical conditions down to much greater accuracy, in doing so you suffer a certain amount of loss to the visual functions, and natural adaptability of the eye to shooting. I quite believe that target-shooting improved thereby, but in this paper I wish to suggest, if possible, some way of making general shooting better, under the varied and trying conditions which we have to be encountered in actual service.

Mr. BAKER: I agree that it would be more desirable, but I am afraid we shall have to long way off it.

The CHAIRMAN: It is my pleasing duty now to ask you to accord to Dr. Forster a vote of thanks for the lecture which he has given us to-day. The hearty and genuine applause which he received at the conclusion of his lecture must have shown him, I think, how thoroughly it was appreciated, and when Captain Pim expressed his thanks to Dr. Forbes for the very able, scientific, and useful lecture he has given, he simply expressed the opinion of everyone who had the pleasure of hearing it. I am very glad indeed that we postponed it, for there were only six present the other day, and I think that number is multiplied to-day at least four or five times. I only wish that this room had been as crowded to-day as I have seen it on other occasions, when, perhaps, matters not quite so interesting were discussed. The impression left on my mind is how very blind we all are without knowing it. That many men go on practising shooting who might well give it up. That is the only cause for regret I have that this lecture should have been given immediately before Wimbledon. If a man should come up and want to make bulls'-eyes instead of paying 5*l.* for entry, should go to an oculist and pay one guinea, and that it was no use his trying, for he would never make a good shot, I think it would be a bad thing for the National Rifle Association. We have heard an exact case point. Captain Pim told us he was a first-class shot himself, but he has not committed that power to his son. But his son is anxious to rival his father, has been expending a lot of money on shooting, and now he is going to take to an oculist, and we shall have no more entries from young Pim at Wimbledon or elsewhere. But the remedy lies, it appears, in glasses, and it strikes me that the opticians will have a great deal to do if all these natural defects of vision can be in a great degree remedied. I was always myself in favour of allowing orthoptics. As regards the question of danger, of course, if I hold the glass at a distance from my eye, I should see very little besides the target, but if I put it near my eye, I see half a mile on each side of the target; therefore, so used, I do not believe it is any danger. No doubt, when shooting in the back position, the pin-holes are a comparatively long way off, there was some danger, but now that the back position is mostly done away with, I do not think orthoptics are dangerous. The position of the back-sight has been referred to. There is no doubt about it, that as a matter of course, the older he wishes to have the back sight further removed. The Officer at the Enfield has invented a new rifle which has gone out for trial, but I am sure that no man who ever shot with a rifle in his life would ever have placed the back sight where he has placed it. The back sight is put so far back, and is of such a nature that I am certain no practical man who understands shooting and sighting would ever turn out such a rifle as the one referred to. As regards army shooting, I think General Blundell must feel that it is very desirable to overlook the eyes of the Army in that respect, and when men are taken out to the target after day, and do not improve, it should be seen whether it may not be due to a defective state of vision. I do not think we can expect a large vote every year for spectacles. I wish General Walker were here, because I should have asked him the reason why so many Germans wearing glasses—whether it is that they are short-sighted or over-study in schools or elsewhere, as we are told, or whether it is what I have heard amongst the Officers especially—that they put on plain glasses, which are really not short-sighted glasses, to give an idea that they are very studious.

working very hard with a view to promotion. I do not know with what truth that is said, but I do not expect myself that we shall ever see the British Army a spectacled army. With regard to judging distances my belief is that, beyond a certain distance, teaching men to judge distances is all rubbish; it is all chance, unless you have some sort of instrument, and it will come to that that we shall have some sort of instrument practically for judging distances. I do not believe it is practicable to get a whole regiment to shoot up to the full range, or anything like it, of the Martini, with accuracy. You will not find 600 men up to the same mark in a regiment, any more than in an orchestra all the players will be able to play as well as a certain number of crack violinists in it. We probably may not return to the flank companies of the olden days; but Captain Pim will bear me out, that in the Devil's Own, Colonel Brewster, the commander of that distinguished corps, and a distinguished rifleman himself, when his regiment was sent out, instead of sending this or that company out, his word of command was, "Marksmen to the front;" so that when the enemy was at a distance he sent out the marksmen, and when the fire got nearer the others took it up; and I believe that if you have picked marksmen in sections, working under trained section leaders, who are able to judge distances for them, you will get certain good results in that way, and make use of the good-sighted men, and when the work becomes rougher and nearer and such accuracy is not necessary, you can then use the mass of your troops. You will thus save ammunition and do more effective work than you do under the present system of attack. I do not know that I have anything else to say further than this, that as regards the question of lights at sea, I would remind Captain Pim, that either last year or the year before a Committee was appointed to inquire into this matter. As regards fishing vessels, I quite forget what the report was, but it all turned on what would be the best colour and arrangement for lights, and if Captain Pim will refer to the report of the Committee in question, he will find some information with respect to the distance at which different coloured lights can be seen. Mr. Birkbeck, who has taken such an active part in the Fishery Commission, was in the chair. I have no further remarks to make. I apologize for having ventured to make these, and I ask you to give the most cordial and hearty thanks to Dr. Forbes for his interesting lecture.