search Station, Long Ashton, Bristol, has now directed attention to the considerable amount of waste material from the saw mills, and has made analyses showing that this also yields a residue containing from 6 to 10 per cent. of potash (K_2O). Mr. Gimmingham points out that the wood scraps, sawdust, and shavings from planing machines, etc., are produced in enormous quantities in every sawmill in the country. Some of this material, and notably the sawdust, is saleable in certain localities, but the great bulk of it is available for conversion into ash. In many cases this is already done; the wood is used as fuel, either alone or mixed with coal, and the ash is then readily obtained. It is interesting to note that in these cases the flue dust also contains a considerable proportion of potash, in one case as much as 9 per cent. being found. From the fertiliser point of view the admixture of coal with the wood is a disadvantage, and in view of the fact that the pure ash is worth anything from 25*s*. to 50*s*. per ton as fertiliser, it is well worth considering whether greater economy could not on the whole be effected by leaving out the coal and using wood waste only for fuel.

OUR ASTRONOMICAL COLUMN.

COMET NOTES.—An ephemeris of comet 1915*a* (Mellish) is published in the *Astronomische Nachrichten*, No. 4802, being a continuation of that published in No. 4801. It gives the magnitude as 5·5 on July 2, the brilliancy decreasing steadily afterwards. The comet will be a conspicuous object in July for southern observers, but its large southern declination during that month renders it unfavourable for observation in higher latitudes. Fortunately the southern declination will rapidly decrease, and the comet will be again visible in these latitudes. Dr. Crommelin, writing in *Knowledge* for June, hopes that it may still be a naked-eye object. The orbit, he says, "shows a slight resemblance to that of comet 1748 II., which was seen only on May 19, 20, and 22, in 1748, so that the elements are not very well known. Identity of the two comets is perhaps just possible, but not probable." A continuation of the ephemeris of the periodic comet Tempel 2 is also printed in *Astronomische Nachrichten* No. 4802, giving positions down to the end of next August.

ORBITS OF ECLIPSING BINARIES.—No. 3 of the Contributions from the Princeton University Observatory contains an important study of the orbits of eclipsing binaries by Dr. Harlow Shapley. It may be remembered that it was in 1912 that new methods were introduced for the computation of the orbit of an eclipsing binary, and these have permitted the rapid development of this phase of double-star astronomy. It has now become possible, as Dr. Shapley remarks, to derive as much information concerning binary systems in general, and their bearing on stellar evolution, from the orbits of eclipsing variables as from spectroscopic binaries or visual doubles. These new methods and their development are due to Prof. Russell and Dr. Shapley, and the present publication gives briefly the theory underlying the methods, and exhibits in some detail how these methods are employed in dealing with the considerable variety of problems that arise. A preliminary report in 1912 dealt with the orbits of forty-four stars, and later the results for eighty-seven stars were published. The present discussion represents the complete investigation of practically all the material available up to the present time, and contains in final form the treatment of ninety eclipsing variables. Dr. Shapley for the last two and a half years has been using the equipment of the Princeton Observatory to add to the material, and has made about 10,000 light measures with the polarising photometer. This has been done to obtain complete light curves of interesting stars, to fill up gaps in published series of observations, and to correct existing light curves. In the arrangement of the text the author has, as far as possible, kept the tabular matter separate and brought this together in the appendix. On p. 124 he summarises some suggested investigations on eclipsing binaries, and points out lines along which further investigations are desirable and could be accomplished without serious difficulty.

THE VARIATION OF LATITUDE DURING 1914·0–1915·0.—Prof. Albrecht publishes, in the *Astronomische Nachrichten*, No. 4802, provisional results of the international service for the determination of the variations of latitude. Fortunately, the war has in no way disturbed the observations at the six stations, so that the determination of the path of the pole has been continued as on former occasions. The communication is accompanied by the usual chart showing the track of the pole for the period 1909·0 to 1915·0, indicating an increase of amplitude of swing since the latter end of the year 1913.

THE SOCIETY FOR PRACTICAL ASTRONOMY.—The April-May number of the Monthly Register of the Society for Practical Astronomy, Chicago, has just come to hand. While the astronomical observations published in it are very brief, dealing only with some observations of comets and a short report on the planetary and lunar section, attention is directed to the need of a new section which should have for its object the furthering, in all possible ways, of the teaching of elementary astronomy according to modern methods. The writer of this appeal, Dr. Mary Byrd, formerly director of Smith College Observatory, refers to a circular letter issued some years ago by the American Astronomical Society, in which it was stated:—"The society considered the deplorable ignorance of persons, otherwise intelligent, in regard to everyday phenomena of the sky, and the fact that astronomy lags behind the other sciences in adopting the modern method of laboratory work by the student." As a move in the direction of remedying this defect the author advocates a scheme of organised effort to make elementary astronomy a practical study, and calls on the great body of amateurs in America to enlist themselves in the new movement.

AIMING WITH THE RIFLE.

SO many people are now learning to shoot with the rifle that it is profitable to consider some of the difficulties they are likely to meet with. These difficulties become greater as the age of the learner increases, and they may be minimised or accentuated by the lighting of the range at which the learner practises. A discussion of the lighting of rifle ranges, which took place at the monthly meeting of the Illuminating Engineering Society on May 18, shows very clearly that the existing conditions place artificial obstacles in the way of the learner; and it may fairly be contended that these obstacles never would have arisen, and the path of the learner would have been considerably smoothed, if certain optical principles had been recognised and utilised. Mr. A. P. Trotter, who opened the discussion, gave a very clear account of the difficulties encountered by a man of middle age when he attempts to shoot at one of the many indoor ranges which have recently been opened; it has appeared to me to be worth while to attempt to explain some of these difficulties, in order that those which are avoidable may be eliminated.

An experimental arrangement which can be used to illustrate the essential difficulties to be met with in aiming with the rifle, is represented in perspective in Fig. 1. A is a rough model of the eye. It comprises a tube about $1\frac{1}{2}$ in. in diameter and 3 in. long, closed in front with a lens L of about 3 in. focal length; into the back of this tube fits another tube, which carries a screen of ground glass S. B is a sheet of cardboard, with a notch in the upper edge, to represent the rear-sight of the rifle. C is a piece of card cut to a point, to represent the fore-sight of the rifle. D is a circular opaque disc which, for convenience, may be attached to the glass of a window of the room in which the experiment is conducted; this disc represents the "bull's-eye" of the target. By sliding the screen S in or out, either B, C, or D may be focussed; but all cannot be focussed at the same time. If, however, the lens is covered with a piece of card provided with a circular aperture of about $\frac{1}{2}$ in. diameter, A, B, and C can all be focussed simultaneously; and the screen S can be moved in or out through some distance without impairing the clearness of the image on the ground glass. The brightness of the image is, however, much diminished. This illustrates the advantage and disadvantage due to the use of "pin-hole" spectacles. If the card is arranged so that its circular aperture lies over the

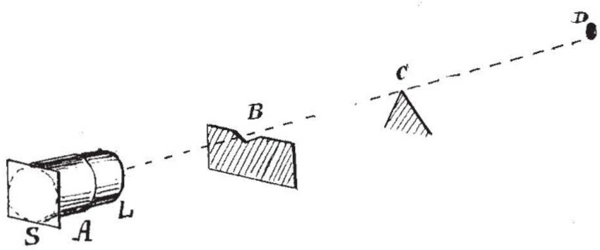


FIG. 1.

middle of the lens, and the images of B, C, and D are formed at the middle of the ground glass screen, the position of the image of either B, C, or D is identical with that of the corresponding image produced, with the card removed, by adjusting the position of the ground glass screen; but if the aperture of the card is displaced towards the edge of the lens L, the various images are displaced both relatively and absolutely.

Further, let the perforated card be removed, and let the screen S be adjusted so that the "bull's-eye" is focussed; then on covering the lens from below by a piece of unperforated card, it will be seen that as the card rises, the image of the "bull's-eye" sinks, while the images of the sights rise. A similar effect can be observed with regard to the eye. If the model eye A is removed, and replaced by the eye of the observer adjusted so that B, C, and D are in alignment, while D is focussed, it will be found that if the pupil of the eye is gradually covered from below by a piece of card the "bull's eye" appears to rise above the sights.[1] To understand this result, it must be remembered that the image produced on the retina is inverted, and that an absolute depression of the image is interpreted as an apparent rise of the object viewed. The apparent motion referred to is very marked when the light is dim and the pupil is expanded; it can only be noticed with some difficulty in bright daylight.

[1] See "Spherical Aberration of the Eye," by E. Edser (NATURE, April 16, 1903). Also "Light for Students," by E. Edser (Macmillan and Co.), p. 165.

Returning to the arrangement represented in Fig. 1, it will be found that when the "bull's-eye" is focussed by the unstopped lens L, raising the card B causes the image D to sink. Similarly, in a dim light, on bringing the rifle into position so that the rear-sight intercepts light from the lower part of the pupil, the "bull's-eye" appears to rise. In a great number of cases, when the fore-sight is brought too high so as partially to cover the "bull's-eye," the latter appears to swell at its upper left-hand edge (at about "half-past ten"), and sometimes this swelling develops into a second "bull's-eye" detached from the first one.

The following important phenomena can also be noticed:—

(1) On focussing the bull's-eye with the lens L unstopped, the image of the fore-sight C is surrounded by a narrow penumbra; a similar but wider penumbra borders the image of the rear-sight B. If the lens is now stopped down, the circular aperture of the card being over the middle of the lens, the images of B and C become sharp, and it will be noticed that *the images of the edges of the sights now have the same positions as the edges of the corresponding penumbras produced by the unstopped lens.* Thus it appears that in aiming with the rifle, when the bull's-eye is focussed, the top of the narrow penumbra surrounding the fore-sight should be brought level with the top of the wider penumbra bounding the shoulders of the V or U rear-sight. I have found that this procedure leads to consistent and good shooting. A peculiarity of the penumbra surrounding the ocular image of the fore-sight will be mentioned later.

(2) On focussing the fore-sight B with the lens L unstopped, the image of the bull's-eye D becomes much smaller, and may even disappear. The image of the rear-sight is slightly improved. Similarly, when aiming with the rifle, the image of the bull's-eye is diminished in size when the fore-sight is focussed by the eye.

(3) On focussing the rear-sight B with the lens L unstopped, the bull's-eye D disappears, and the fore-sight B becomes smaller and less distinct.

Now young people can alter the focus of their eyes without effort; they see the bull's-eye, the fore-sight, and the rear-sight in rapid succession, so that sometimes they appear to see all three at the same time. In this case sighting is easy. But with advancing age comes the necessity for effort in focussing the eye to different distances, even if this capacity is not lost altogether. For myself, I can read print (even small print) at ten inches from my eye, but a perceptible effort is required to alter the focus of my eyes; and from the result of my own experience, together with that of several men in a condition similar to my own, I strongly advise that the bull's-eye only should be focussed, the tip of the fore-sight being brought just below the bottom of the bull's-eye and level with the top of the penumbra which bounds the shoulders of the rear-sight.

A peculiarity of the image of the fore-sight, when the bull's-eye is focussed by the eye in a dim light, must now be mentioned. At first sight the appearance presented is that of three images[2] standing side by side, the central image being the darkest. On careful scrutiny, however, two overlapping images only are seen, the portion common to both being darker and giving the appearance of a third image (Fig. 2, A). No such appearance can be obtained with the model represented in Fig. 1; we must therefore seek for its explanation in some defect peculiar to the eye. With a little care a somewhat similar double image can be seen even in fairly bright daylight. Let the pointed tip of a lead pencil be placed (for steadiness) upright against the glass of a window, and then, with one eye

[2] These appear to be the three images mentioned by Mr. Trotter.

closed, look with the other eye past the pencil at some distant object; a narrow penumbra will be seen round the tip of the pencil, and on observing this carefully it will become evident that there are really two overlapping images of the pencil-tip standing side by side, the portion common to the two being dark (Fig. 2, B). The nearer the eye is to the pencil, the greater is the separation of the images; in daylight, separation is just visible (to me) at a distance of about 3 ft. If the *right* half of the pupil is now covered by a card, the *left* image disappears; on covering only the *left* half of the pupil, the *right* image disappears. If the pencil is placed in a horizontal position, the appearance is quite different; the pencil now appears sharply defined laterally, but its tip ends in a penumbra (Fig. 2, C).

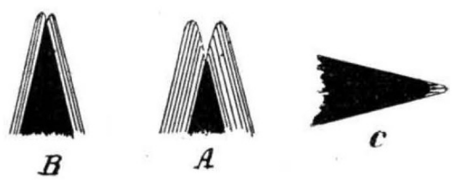
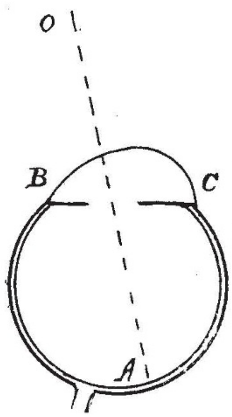


FIG. 2.

It appears to me that these phenomena may be ascribed to the peculiar shape of the cornea. It has long been known that the cornea is not spherical, and Sulzer has found that its form does not agree with any known simple surface, and that it has no axis of symmetry. In the majority of cases the nasal side of the cornea is flatter than the temporal side, so that the section of the cornea of the right eye, when viewed from above, resembles BC, Fig. 3. The visual line OA (*i.e.*, the line along which the most direct ray travels from the object O to the most sensitive portion of the retina A) passes through the flatter portion of the cornea; and the centre of the pupil is also behind the flatter portion of the cornea. Thus when the light is good, and therefore the pupil is small, the rays which form the image on the retina pass through the flatter portion of the cornea; and under these conditions we obtain the best ocular images.



Now, in aiming with the rifle in a dim light, the bull's-eye being focussed, if the cornea were spherical, there would be a number of overlapping images of the fore-sight, thus giving rise to the appearance of a single dark image surrounded by a penumbra. The peculiar shape of the cornea, however, appears to cause a segregation of these images into two groups, giving rise to two overlapping images side by side. The light which enters the right eye through the left part of the cornea (*i.e.*, the flatter portion) gives rise to the right-hand image; that which enters through the right (more strongly curved) portion of the cornea gives rise to the left image. So far as my experience goes, the right image is the darker and better defined of the two; and we might expect this to be the case, since it is formed by the rays which traverse that part of the cornea which is utilised when vision is at its best. It therefore appears that *the right-hand image of the fore-sight should be aligned with the middle of the notch of the rear sight, its tip being just below the bull's-eye at "six-o'clock," and just level with the top of the penumbra that bounds the shoulders of the V or U rear-sight* (Fig. 4). In a dim light it is well to allow for the fact that the bull's-eye is apparently raised, by leaving a distinct white line between the tip of the fore-sight and the lower side of the bull's-eye. In all cases the fore-sight should at first be aligned some distance below the bull's-eye, and raised to its final position just before firing.

When the rifle is aimed in daylight *with a bright sky overhead*, light is reflected from the upper rim of the rear-sight into the eye. When the bull's-eye is focussed, this light forms three bright linear images in the eye. The lowest bright line occupies the position of the upper boundary of the black portion of Fig. 4; the middle bright line occupies the position of the upper boundary of the penumbra shown in Fig. 4; while the upper bright line bounds a faint secondary penumbra which is scarcely visible in a dim light. Similarly, if a diaphragm with a narrow horizontal slit is placed in front of an eye focussed to see distant objects, three bright images of the slit are seen. These multiple images, which vary somewhat in position for different observers, and even for the two eyes of a single observer, are presumably due to variations of curvature of the cornea in a vertical plane. Correct shooting can be obtained by aligning the top of the fore-sight with the *central* bright line which bounds the lower penumbra; as this line is clearly seen, it can be utilised as easily as the focussed image of the rear-sight. The advantage of a good overhead light thus becomes apparent.

So far as the lighting of indoor ranges is concerned,

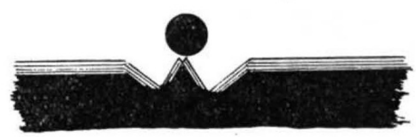


FIG. 4.

it may be inferred that we shall see best under those conditions which approximate most closely to ordinary diffused daylight. The use of a small brightly illuminated target, in a room with black walls and ceiling, could be defended only if it were desired to train people to shoot at a distant searchlight. In such conditions the pupil is distended, all of the troubles discussed above are intensified, with the addition that the glare of the target tires the eyes. Similarly, the glowing filament of an incandescent lamp tires the eye more when it is viewed in a dark room than when it is viewed in daylight. I believe that the best thing to do in connection with indoor rifle ranges would be to whitewash the walls and ceiling, and have a good illumination either with electric glow lamps or incandescent gas mantles, merely taking the precaution that the lamps are shielded (say, by paper shades) from the direct view of the shooters.

So far as the utility of miniature rifle ranges is concerned, it appears to me that this may be easily overrated. It is possible, of course, at one of these ranges to learn to hold the rifle correctly, to become accustomed to accurate sighting, and to press the trigger without moving the rifle. Difficulty, however, arises from the fact that accurate shooting entails compliance with *all three* of these requirements, and bad shooting may be due to a failure in one only. The position of the bullet-hole in the target gives only the net result of all the actions involved; and I have known men to ascribe their failure to get near the bull's-eye to the defective sights of the rifle, or (more rarely) to their own defective sighting, when in reality their bad shooting was due to *pulling* the trigger instead of *pressing* it. It is clear that more rapid progress can be made if the learner can discover the particular defect to which his failures are due. Various devices have been used for this purpose.

In the sub-target the rifle is mounted on a universal joint, and on pressing the trigger a hole is punched in a card, thus indicating the direction in which the rifle is pointed at the instant. This appliance is expensive, and since the rifle is not free, defects due to trigger-pulling are not made evident.

The aim-corrector is a piece of plain smoked glass mounted behind the rear-sight so that its surface is inclined at 45° to the sighting line. The learner takes his sight through this glass in the usual way; the instructor watches the sights from the side, as they are seen reflected in the glass. Obviously, the instructor must possess considerable skill in order to use this appliance with advantage.

The aiming disc is a perforated metal disc which is placed in the observer's eye like a monocle. The learner aims at the perforation, and any *considerable* motion of the rifle during trigger-pressing can be seen by the observer. This appliance can only be used with advantage at short distances from the learner, and anyone accustomed to the use of fire-arms can scarcely avoid an uncomfortable feeling on watching a gun that is pointed at his eye.

I have devised a simple appliance by means of which most (if not all) of the benefits usually derived

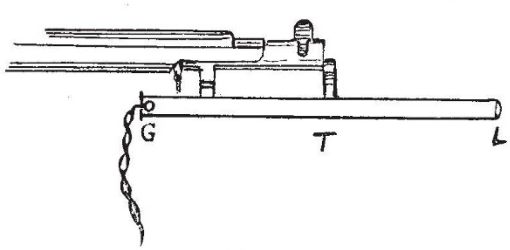


FIG. 5.

from a miniature range can be obtained without the use of ammunition. This appliance is represented diagrammatically in Fig. 5. A metal tube T, which can be fitted to the bayonet standards of a rifle, is provided with a lens L at the front end, and a small electric glow-lamp G at the rear end. The lens L can slide in or out, so that the image of the glowing filament of the lamp can be focussed on a white screen placed near the target. The current for the lamp can be supplied by three or four Leclanché cells; or a battery of dry cells, similar to that used for an electric torch, can be fixed to the tube T, thus obviating the inconvenience of the leads from the lamp to the cells. It is best to aim at a target about 10 yards away; an observer, who need possess no qualifications other than general intelligence and quickness of perception, stands or sits by the target and watches the image of the filament formed on the screen. I have obtained small electric glow-lamps which produce an image approximating in shape to a V. The position of the point of the V, at the instant when the trigger is pressed, can be marked on the screen; and if the rifle is moved during the act of trigger-pressing, the direction of motion, and its extent, can be marked by an arrow. If the position of the point of the V has previously been marked when the rifle was aimed by an expert, the correctness or otherwise of the learner's sighting is seen at a glance. I have found that most learners aim better than they shoot; that is, they sight the rifle on the bull's-eye with some approach to correctness, and then pull it away while they are actuating the trigger. If the learner is particularly bad at sighting, the rifle may be supported on a sand-bag or tripod stand, and sighting can be practised until a satisfactory "triangle of error" is obtained.

I have found, by the aid of the appliance just described, that different people can aim a rifle with perfect consistency according to the rules given earlier in this article.

EDWIN EDSER.

THE SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES.

THE twentieth annual congress of the South-Eastern Union of Scientific Societies was held at Brighton on June 2–5, under the presidency of Dr. J. S. Haldane, F.R.S. The presidential address was entitled "The Place of Biology in Human Knowledge and Endeavour." Dr. Haldane gave to his hearers a deeper insight into the inexhaustible fulness of reality which science only partly explores, and puts us on our guard against the error of mistaking partial and abstract results for complete knowledge. He explained the marvellous nicety of the natural regulation of the act of breathing, and of the means by which constancy in the composition of the blood was maintained, and used these instances to prove the unwisdom of declaring ourselves to belong to either of the opposing schools of "mechanists" or "vitalists." In face of the evidences of "organic determination" which these instances gave, neither of these hypotheses could satisfy. In like manner, the partial character of even the highest conception of biology and of all science must be recognised, and recognising this, we should not be ready, merely because they are not susceptible of scientific treatment, to undervalue or ignore those higher elements of human experience which we designated moral and spiritual.

Incidentally, in noble and moving language, Dr. Haldane referred to the great struggle which is occupying all minds. "The flashes of war have lit up for us this spiritual world. The sense that it is our plighted duty to deal with an infamous disregard of elementary right has sent hundreds of thousands of our best and truest into the fighting line, and is marshalling the whole activities of our nation and its Allies in a manner in which they never were marshalled before. . . . Yet we are waging this war in the absolute determination to conquer, cost what it may. For we are fighting, not merely for our own advantage or safety, but for a higher duty; and the faith that this higher duty is a real one, and that in following it we are at one with that spiritual reality which is the only reality, gives us a resolution, a courage, and a confidence, which could come from no other source."

In a paper on the problem of terrestrial and fluviatile shellfish, Mr. Hugh Findon dealt with the genealogical history of genera of molluscs, tracing their ancestry by the aid of the geological record, and finding the ancestral habit at one time marine, and at another a fresh-water one. "As I read the geological evidence the history of the river mussels is exceedingly interesting. A line of marine mussels persisting from earliest ages until the present time gave off a branch which in Carboniferous times took to a fresh-water life, Anthracosa, and again in the Miocene period repeated the phenomenon in Dreissensia. The first branch, with the exception of Anthracosa, returned to the sea and gave rise to another persistent family, that of Trigonia. About half-way along this second line a branch was given off which also entered a fresh-water existence during the age of the Purbeck, and this time successfully, for the present age witnesses Unios flourishing as they never did before in the world's