It does appear plain that the village institutes have a fine opportunity for giving encouragement to continuation rural education; they not only miss the opportunity, but, at the same time, unwittingly are the cause of there being no demand for an evening school. Opportunities for the village youth to spend aimlessly and uselessly all their spare time are to be deprecated.

In one West Riding village the influence of the opening of a new institute was shown by the total exodus of the members of the existing evening school. Even the moral obligation to complete their attendances, so as to save financial losses upon the school, failed to bring them back again. The billiard-ball was rolling, so opportunities for the making of more fit citizens were sent flying. The result was not a moral triumph for the ex-students.

May one suggest that in the future some donor of an institute, or someone who by their contribution has made it possible for trustees to lease an institute at a nominal rent to a committee of management, should insert a proviso in their deed of gift that younger members of the institute are to attend continuation educational work at the village school? Such a proviso might be open to elimination if found, after an extended trial, to be prejudicial to the institute's success.

There should be an educational side to every village institute; it might be an attached rural association or club for the further advance of rural interests. Such an association might hold meetings periodically for discussions upon general agricultural matters. Samples of manures and feeding stuffs, along with a consideration of current values and prevalent adulterants, are important matters, and should be undertaken by the suggested rural club. The leaflets of the Board of Agriculture would be suitable for elucidation and discussion; their distribution could be carried out by the club.

Village halls have been in the past the centre of the arts and crafts movement; in some parts of the country they are yet. The development of handwork in the elementary schools of the rural districts should again revive the use of the village hall. Such a revival requires funds. The Board of Education and local authorities place at the disposal of committees doing educational work of a manual nature liberal grants. Some of the wealthy trade guilds might be disposed to find funds for a village development of arts and crafts if the work had an industrial basis. In this way might be developed in the village, as in Germany, a large number of small workshops going hand in hand with agriculture.

The village institute and evening school would not become competitors by both taking up educational work; they would become helpers. Admission to the institute's higher work should preferentially be given to those who had thoroughly prepared themselves for it by a satisfactory course of preparatory work at the evening school. In short, the institute would be regarded as the technical school of the village, giving, amongst other work, practical and theoretical instruction on the greatest of all industries—agriculture.

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Avogadro's Hypothesis (or Law).

IN Prof. Tilden's "Life of Mendeléeff" in the current number of the Journal of the Chemical Society, I see that he refers repeatedly to the "law" of Avogadro. Sir William Ramsay, in his "Modern Chemistry," speaks of it as a "hypothesis," and this has surely been, until recently, the practice of chemists.

I think there is a growing tendency to speak of it as a law. This, doubtless, arises from the strong confirmatory evidence provided by modern physical chemistry. It is desirable, in the interests of students and of exactitude in scientific nomenclature, that some decision should be come to as to which term should be used. This may necessitate very careful definition.

A discussion of this matter, in which teachers will give reasons for their choice, should prove of value.

S. H. WOOLHOUSE.

Parmiter's School, Approach Road, Victoria Park, N.E., January 17.

"A Japanese Priest in Tibet."

WHATEVER may be the demerits of Mr. Kawaguchi's "Three Years in Tibet," reviewed in NATURE of January 13, the title of the book is, according to the Eastern habit of reckoning, quite accurate. Mr. Kawaguchi spent part of 1900, all 1901, and part of 1902 in Tibet—three years. A child in Japan, if born on December 31, begins his second year on January 1, and on the succeeding New Year's Day may be regarded as having lived for three years, although he may be only 367 days old!

C. G. KNOTT.

University of Edinburgh, January 17.

STANDARD MEASUREMENT IN WAVE-LENGTHS OF LIGHT.

THE employment of the principle of the interference of two rays of monochromatic light, derived from the same source, one retarded behind the other by having to traverse a longer path, for the production of rectilinear interference bands constituting a scale of half-wave-lengths, has now been brought to such perfection that this highly refined scale may be used for the measurement of short distances or small movements of any description whatsoever. The accuracy is absolute to the tenth part of a scale division, the twentieth part of a wave-length of light, and is actually measurable with the most ordinary micrometer to the one-hundredth of a scale division, corresponding to the two-hundredth part of a wave-length. Now a wave-length of even the grossest radiations employed, those of red light, derived from either cadmium vapour (0·0006438 mm.) or hydrogen (0·0006562 mm.), is a forty-thousandth of an inch, so that the measurable unit is an eight-millionth part of an inch.

The finest trustworthy measurement by mechanical means (such as the Whitworth machine) or micrometric devices (such as the most refined thickness measurer) is the one-thousandth of a millimetre, or the twenty-five-thousandth of an inch. Moreover, the amount of possible error with either of these mechanical methods of measurement or the interference method is from one to two units of the respective scales. Hence the interference method is only subject to a possible error of one three-hundred-and-twentieth the magnitude of that to which the mechanical mode of measurement is liable.

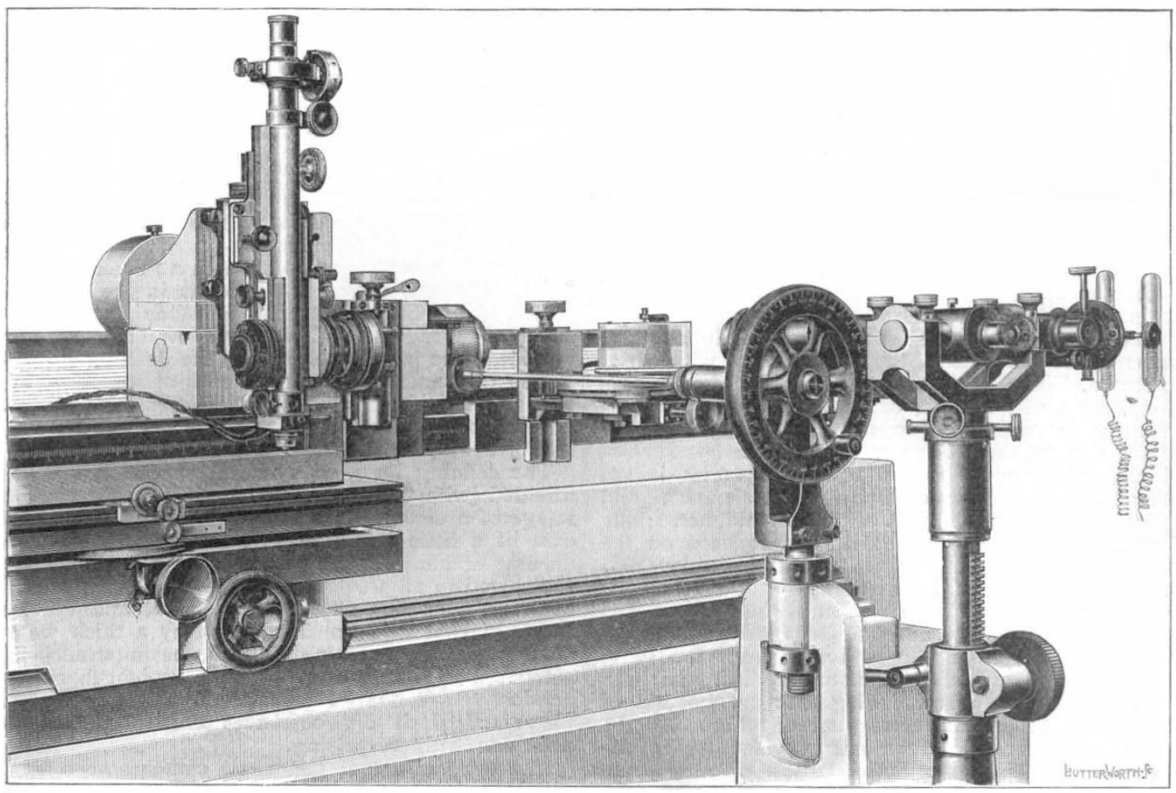
The interference method was first seriously employed by Fizeau, who utilised it for the determination of the thermal expansion of crystals and other small bodies. It was materially improved by Abbe and Pulfrich, and more recently both for the same crystallographic purpose and for general purposes by the writer, who has also extended its use to the measurement of the modulus of elasticity of crystals and small bodies or small quantities of substances in general.

It will be remembered also that Prof. Michelson, of Chicago, has recently adapted his entirely different mode of producing interference fringes, in this case circular, to the determination of the number of wave-lengths of red cadmium light, which he has proved to be the most homogeneous of all radiations yet known to us, in the French metre. By employing a graduated series of glass-plate *étalons* or intermediate standards, each double of the preceding one, commencing with a basal one of half a millimetre in which the actual number (1212) of half-wave-lengths was counted, the number of wave-lengths of red cadmium light in the metre was eventually found to be 1,553,163. This number has since been confirmed by the independent method of Fabry and Perot, in which circular fringes are also produced.

Three years ago the writer was invited by the Standards Department of the Board of Trade to adapt

his interferometer to the purposes of a wave-length comparator of measures of length, and a memoir recently published in the Philosophical Transactions of the Royal Society (Phil. Trans. A, 1910, vol. ccx., p. 1), with the consent of the President of the Board of Trade, describes the instrument, which has now been installed in the Standards Office. The memoir also comprises an appendix concerning the possible employment of wave-length rulings on metal as defining lines on standard bars, with suggestions for their use along with the interference bands of the interferometer, in an original method of determining the total number of wave-lengths in the British yard.

A general view of the interferometer and one of the duplicate microscopes of the comparator, together with sufficient of the bar-carriage to enable some idea of the whole apparatus to be gained, is given in the accompanying illustration.



Central part of comparator, showing inferometer.

The whole instrument is mounted on a large stone block, resting on isolated concrete foundations. On a small stone pedestal, similarly isolated, in front of the large block, rests the pedestal of the auto-collimating telescope and attached Geissler tube of the interferometer. In the common focal plane of the telescope objective and eye-piece, opposite the junction of this main optical tube with the rectangularly attached side-tube carrying the Geissler tube, a small totally reflecting prism is arranged, half covering the focal aperture. A still smaller rectangular stop or opening in a plate in front of and almost touching that one of the perpendicular prism faces which is directed towards the objective, and lies in the focal plane very close to the edge, dividing the closed half from the open half, is the effective source of the interfering light; the rays from the Geissler tube, received on the other face of the right-angled prism, are arranged to fill this stop after reflection from the hypotenuse of the prism. The rays proceed from the stop to the objective, which they are arranged to fill with light, and thence pass out of the telescope as parallel rays, in the path of which the dispersion and interference apparatus is placed. The rays return to the telescope from the latter along practically the same path, but after re-entering the telescope, instead of returning to the little rectangular stop, their origin, they are deflected just sufficiently to one side to form an image of the stop, the same size as the original, in the open semicircular aperture of the focal plane, within a couple of millimetres of the real stop. This closeness to identity of path of the outgoing and incoming rays, and consequent normal incidence on the reflecting glass surfaces of the interference apparatus, is largely responsible for the magnificent field of parallel straight-lined interference bands which the author's interferometer affords, for it fulfils an essential condition for perfect interference.

With the ordinary eye-piece in position, the images of the stop reflected from the various surfaces of the interference apparatus can be focussed, adequately magnified, and viewed during their adjustment to the theoretically ideal positions. But when this eye-piece is replaced by a special one consisting of a Ramsden micrometer combined with an additional lens between the latter and the focal plane, the telescope is converted into a low-power microscope, which focusses simultaneously the interference bands, a little silvered reference ring in the centre of one of the two surfaces reflecting the interfering light, and the micrometer spider-lines. There are two parallel

vertical spider-lines; one is adjustable by the left drum-head of the micrometer, so as to be able to set it at any convenient distance from the other in order to include a single band and most of the reference ring between them; and both are moved together by the other (right) measuring drum, in order to be able to determine the band-width and any fraction of a band which may have passed the reference centre.

The dispersion apparatus consists of a Hilger constant-deviation prism, which enables the desired spectrum ray to be isolated from all others, and that alone delivered to the interference apparatus. The rays are deviated exactly at right angles by this prism towards the interference apparatus, the surfaces of which they strike at normal incidence, after which they return through the constant-deviation prism (thus securing double dispersion) to the telescope. The prism is mounted on a divided circle, so that it may be calibrated for the delivery of light of any desired wave-length, if desired, and has numerous adjustments. Such calibration is not essential, however, as the particular image of the origin-stop in the colour corresponding to the spectrum bright line of cadmium or hydrogen can be adjusted visually on removal of the front lenses of the Ramsden eye-piece.

The interference apparatus consists of three circular and thick glass discs, the third of which is of black glass polished an absolutely true plane on its outer surface, which is one of the two important surfaces concerned in the production of the interfering light. It is ground on the back surface, by which it is attached in an adjustable manner to the right microscope of the comparator, the movement of which it is to record. The other two are larger discs of colourless glass, identically similar, the two truly plane surfaces of each disc not being strictly parallel, but inclined at the minute angle of 35 minutes. The left surface of that one nearest to the black glass disc is the second surface concerned in the interference, and approaches the black glass within a millimetre; the second is a duplicate one, merely introduced on the right of it to correct for the slight dispersion produced by the 35′ of inclination, the two being set oppositely as regards the direction of the wedge. The 35′ inclination is just adequate to deflect out of the field of the telescope the reflection from the other (right) surface of the left colourless disc, and both images from the countervailing disc are got rid of by a slight tilt in the rectangular direction. All the many adjustments required are provided for in the mounting of the two colourless discs, on a separate carrier sliding along the face of the upper V-and-plane bed of the comparator.

The apparatus as described up to this point is the interferometer.

The comparator consists of two V-and-plane beds, nearly 7 feet long, of specially homogeneous cast-iron, and worked truly plane with consummate care, together with their contents; they are arranged step-wise, one on the top of the stone block, and the other 7½ inches below and in front. On the upper one slide the two duplicate microscopes, and on the lower one the standard-bar carriage and accessory fine-adjustment fittings. The carriage is given a longitudinal motion, a transverse motion adequate to bring either of the two bars to be compared under the microscopes, as well as fine adjustments for azimuth, height, and level, thus enabling the defining marks on the bars to be readily focussed without touching the microscopes if it is so desired.

Each microscope is carried on a solidly constructed slider on the V-and-plane bed, by which its coarse adjustment for position is effected. The microscope-bearing bracket is not, however, fixed directly to this slider, but to a second one sliding over the first, also with V-and-plane contact, and with the further control of the movement of a cylinder within a cylindrical boring. The fine-sliding is effected by means of a most carefully made screw of fifty threads to the inch, on which the success of the instrument depends, and which carries at its outer end a large milled head for hand rotation, and a worm-wheel of 100 teeth gearing with an endless screw, which can either be rotated by hand by means of a milled head or by means of a shaft and a large wheel seen in front in the illustration. One complete rotation of the latter corresponds to the movement of the microscope and the black glass interference disc to an extent which causes the passage of fifteen interference bands past the reference centre. More than an inch of movement of the circumference of the wheel is necessary to effect the passage of a single band. Two-thirds of the dead-weight of the microscope and slider are taken up by four spring pistons, and the movement of the slider by the screw is only a push in either direction against the walls of a recess in the free slider, there being absolutely no strain anywhere. Hence this movement of the microscope is not only an excessively fine one, but also so steady that the bands pass with a precision which leaves nothing to be desired, and each band may be held for any length of time for counting purposes.

Each microscope is provided with a micrometer eye-piece, with spider-lines arranged as in the interferometer. The fine adjustment is made exceptionally steady and regular. Two sets of objectives are provided, one pair for observing the defining lines in the countersunk wells near the ends of standard bars, with a magnification of 150 diameters, and without penetration of the well by the objective, and the other set for use with the wave-length rulings.

The defining lines, of whatever character, are illuminated (with "critical illumination") by the brilliant image of a distant Nernst lamp, with the aid in each case of a little reflecting prism, a collimating lens, an iris diaphragm, and a glass-plate mirror above the objective, all provided with fine adjustments. This avoids all heating effect on the bars, and the last traces of heat rays are filtered out by a thick water-jacket in front of the lamp and its beam-parallelising lenses. The illumination of the wave-length rulings one-forty-thousandth of an inch apart is excellent with the 1/12th inch dry objectives employed, and the definition truly surprising.

The temperature of the whole comparator room is maintained at the official temperature, 62° F., entirely electrically, both as regards artificial heating and the thermostat, which is original. So sensitive is the latter that the entrance of a person into the room is immediately followed by the extinction of one of the heating lamps to compensate for the extra warmth introduced.

The finest defining lines yet employed on any line-measure bars are those on the platinum-iridium copy of the imperial standard yard. Yet even each of these has a thickness equivalent to fifteen interference bands. The defining lines on the imperial yard itself are three times as coarse. Hence we have now arrived at that stage in the competition between defining lines and refinement of measurement when the latter has far surpassed the former. It was for this reason that the writer took up the investigation of wave-length rulings, with the idea of their possible use as defining lines commensurable with the increased refinement of measurement. Mr. H. J. Grayson, of Melbourne, whose wonderfully fine rulings have recently been

much discussed in microscopic circles, has kindly made a number of rulings of 1/40,000th inch fineness, which preliminary experiments indicated as feasible for the required purpose, on polished speculum-metal and platinum-iridium, which appear, particularly the former, perfectly satisfactory. The forty-thousandth of an inch being the wave-length of red hydrogen or cadmium light, the distance between two lines ruled at this interval corresponds to only two interference bands. With the 1/12th inch dry objectives the lines, moreover, are as cleanly cut as spider-lines, and the thickness of a line is less than half a wave-length. Five such lines are ruled in succession, the central one being considered as *the* defining line. A strong finder-line is ruled on each side of the five, and two other strong ones at right angles in order to localise a central part of such a system. It appears perfectly feasible to carry out a stepping-off process for the counting of the total number of wave-lengths of cadmium red light in the British yard, in which such rulings would take the place of the glass plates of the Michelson or Fabry and Perot *étalons*, a base line of the thirty-second part of an inch being first actually counted in bands with the aid of the interferometer, between limits defined by two such systems of rulings. The final fraction of every stage in such a process could be absolutely checked by the interferometer in all cases where Michelson found it possible to do so, that is, so far as interference bands are still visible, about four inches; and, as it has already been proved that the accuracy with the rulings is almost as great as with interference bands, this checking ceases to be as imperative as when only the coarse existing defining lines are available. Hence, the future before these rulings appears likely to be both interesting and important.

A. E. H. TUTTON.

SOME NEW NATURE BOOKS.[1]

(1) IN this series of pleasantly written essays Mr. Larken gives an account of some of those features of English (and Scotch) country districts which usually appeal to nature-lovers. The author's habit of passing lightly from one topic to another but distantly connected with it produces a certain disjointedness of style and some needless repetitions, but, taken as a whole, his book is quite good to read, and his knack of interesting one in a disputed point and then abruptly leaving it unsettled is well calculated to stimulate personal observation on the part of his readers.

When attempting to draw conclusions himself, however, he is less happy, being prone to derive the inherited instincts and habits of an animal directly from the experience of its ancestors. Moreover, one has rather frequent cause to doubt the accuracy of his statements; for example, anyone familiar with the Caligidæ, and the tightness with which they can adhere, either in or out of the water, even to the smooth sides of a glass dish, will certainly question the remark on p. 219 that a salmon "leaps . . . into the air for the purpose of getting rid of the sea-lice which are attached to him." That "the Brimstone is a genuine child of spring" in contrast with the hibernating Vanessid butterflies (p. 244) is contrary to the experience of other entomologists; and "Humming-Birds of New Guinea" (p. 192) should presumably read "Sun Birds of New Guinea," for humming-birds are confined to western America and its islands.

The book is illustrated with a profusion of excellent plates, chiefly from photographs. As the greater part of it is concerned with ornithological matters, it is not surprising to find that the majority of the illustrations are of birds' nests. The plate of the comma butterfly, which we reproduce, is one of a short series of admirable insect studies.

(2) These four little volumes will be useful to those who wish to interest children in natural history. They treat of the varied aspects of their several subjects in a clear and interesting manner, and are well illustrated by plates (both coloured and from photographs) and by figures in the text. One hesitates to criticise such admirable books at such a low price, but the value of some of the plates would certainly be increased if they could be brought more closely into connection with the chapters which they illustrate; and where this is impossible reference should be made to them in the text. Some statement of the scale of

Comma Butterfly. From "Leisure Hours with Nature."

many of the figures would make these much more useful; in chapter ix. of "The Common I Know," where this is particularly needed, it could easily be made by the insertion beside each figure of a line indicating the length of the living specimen. On p. 30 of the same volume the association of two figures of plants drawn to different scales is apt to mislead. But even as they stand we are far from wishing to condemn the figures. Apart from size, they show clearly the salient characters of the objects described; the reproduction of the photographs has been beautifully executed, and the coloured plates are wonderful at the price. We can thoroughly recommend the books for (elementary) school use.

(3) This "collection of literary extracts to accompany a course of nature-study" includes prose and poetry, with a variety of subjects ranging from Ruskin's "Plants" and Thoreau's "Brute Neighbours" to fairy stories such as "The King of the Vipers" and Ruskin's "Visit from the South-West Wind." Several of the extracts are old favourites

1 (1) "Leisure Hours with Nature." By E. P. Larken. Pp. xv+263. (London: T. Fisher Unwin, 1909.) Price 5s.

(2) "The Wood I Know"; "The Meadow I Know"; "The Stream I Know"; The Common I Know." Edited by W. P. Westell and H. E. Turner. Pp. 77 each. (London: J. M. Dent and Co., 1909.) Price 8d.

(3) "The Ruskin Nature Reader." Intermediate Book. Selected and edited by G. R. Bennett. Pp. x+180. (London: J. M. Dent and Co., n.d.) Price 1s. 6d.