teresting experiments on 'Binocular Factors in Monocular Vision.' This title is somewhat misleading. The essential characteristic of binocular vision consists in the simultaneous formation of slightly dissimilar images on the two retinas, with corresponding modification of the perception of depth in space. Mr. Judd's experiments relate to variation in direction of the two visual lines, with resulting production of double images; but fusion of these images is an indispensable requisite for the attainment of any binocular perception.

It is well known that most persons fail to perceive double images as phenomena attendant upon binocular vision. To perform binocular experiments the observer must have some training in the muscular control of the eyes, and also in visual perception. Such experiments occupied much of my attention some years ago (*American Journal of Science*, 1881–1883). In performing the first experiment described by Mr. Judd it is very easy to catch the heteronymous image, and by proper control of the eye to stop its motion instantly. The appearance of unrest of the object, to which he refers, is due to the motion of this image during the instant before fusion is attained. The visual line of the closed eye, as Mr. Judd correctly observes, does not converge toward that of the open eye. Since fusion of images is attained in natural binocular vision and without any conscious effort, on suddenly opening the unused eye, unconscious motion of both eyes results until fusion is secured. But the vision is strictly monocular until such fusion is completed, and the momentary illusion is not a binocular factor in such vision.

The experiment is perhaps most easily accomplished by covering one eye with the hand and suddenly removing this, instead of bringing the muscles of the eyelids into play. If the open eye be directed to some well illuminated object of known diameter and at a known distance, such as a clock dial, the angular displacement of the heteronymous image is easily found. It is only necessary to control the unused eye, resisting the tendency to secure fusion and noting the interval between corresponding edges of the two overlapping images. The ratio of this to the distance gives the angle.

The unused eye will in most cases be so directed that the two visual lines are approximately parallel. In cases of strabismus, external or internal, this parallelism is, of course, lost, but in such cases there is usually no power of binocular perception, one eye being habitually depended upon to the exclusion of the other.

When control of the eyes is lost temporarily through drowsiness the uncontrolled relation of the visual lines may be ascertained by winking one eye, if the observer is enough interested in binocular experiments to remember this, and to do this, in his semi-conscious condition. I have done so repeatedly, and have always found in my own case that the double images were homonymous; which indicates that the visual lines were crossed instead of divergent. I have watched the eyes of others under such conditions. In some cases the contraction of the rectus muscles was seen to be internal, in others external. No general rule on this subject can be formulated. It seems highly probable, however, that after consciousness becomes complete all the rectus muscles are completely relaxed, with more or less divergence of visual lines. By the aid of stereographs upon which the stereographic interval exceeds the observer's interocular distance, binocular vision by optic divergence is readily attained after a reasonable degree of muscular control of the eyes has been attained by practice. But for obvious reasons the external rectus muscles are comparatively but little under the control of the will, and 7° or 8° of such divergence is probably about a maximum for normal eyes.

I have elsewhere shown (*Am. Jour. Sci.*, May, 1882) that the ciliary muscle is also subject to the control of the will, though its action is most generally automatic. My observation accords with that of Mr. Judd that vision with a single eye is rarely if ever equal in distinctness to that with two eyes. But the accommodation of the single eye improves with time.

W. Le Conte Stevens.
Rensselaer Polytechnic Institute,
Troy, N. Y.

THE NORTHERN DURCHMUSTERUNG.

The Durchmusterung charts of the northern

sky are indispensable to every active astronomical observatory and to every astronomer who wishes to study the fainter stars. Unfortunately, the original edition of this work is exhausted, so that copies can no longer be supplied. A new edition is being prepared by the Bonn Observatory, and will be published shortly, provided that subscriptions for a hundred copies, at seventy Marks each, are promised before May 1, 1898. The price is very low, considering the amount of material furnished. After that date the price will be raised to one hundred and twenty Marks. The Astronomical Conference held at the dedication of the Yerkes Observatory appointed the undersigned a committee to aid this project. Orders for copies may be sent to the publishers, Messrs. A. Marcus and E. Weber, Bonn, Germany, or will be transmitted to them by any member of the committee. It is proposed to publish a list of American subscribers, and it is hoped that at least fifty copies will be taken by American astronomers. Since charts deteriorate rapidly by constant use several copies should be taken by each of the larger observatories. The members of the committee have shown their appreciation of the value of this work by ordering twelve copies for use in the institutions under their direction. It is of the greatest importance that the subscription list should be filled, as it is probable that in the future many similar enterprises may be undertaken, whose success will depend upon that now attained.

EDWARD C. PICKERING,
J. H. HAGEN, S. J.,
M. B. SNYDER,
Committee.

SCIENTIFIC LITERATURE.

Theoretical and Practical Graphics. By FREDERICK N. WILLSON, C.E., A.M., Professor in the School of Science, Princeton University. (Author's Edition.) 1897. 4to. Pp. viii + 264 + Appendix.

This is a most attractive work, not only conquering elementary graphics entire, but containing much more of highest geometric interest, including a fairly complete course on higher plane curves.

The part of the subject where Church so long held supremacy in America, with his Descriptive Geometry, justly appreciated for its elegance, is paralleled by Professor Willson in his chapter I. and chapters IX.–XII., 117 pages in all, including 219 figures in the text, where he not only covers with equal conciseness and elegance the matter of Church's 138 pages of text and 21 pages of illustration (102 figures), but in addition has treated many new and important matters, such as the Conoid of Plücker (articles 333, 356, 477), a favorite surface of Sir Robert Ball, applied in his Theory of Screws, which itself may be looked upon as in part an application of non-Euclidean geometry, also the Cylindroid of Frézier (§§ 333, 360, 489), the corne de vache (§361, 475–6), and some special helicoids (§ 480–4), and also has covered the Third Angle (or 'shop') method of employing descriptive geometry, and given a very full treatment of development (§§ 405–20). The mathematical surfaces are beautifully illustrated.

The general plan of the book, while providing a comprehensive graphical training in the form of a progressive course, admits of specialization, of shorter courses, with noticeable flexibility. In fact, eight sub-groupings are indicated for independent courses. Comparison with the special treatises scrupulously cited shows the extent of matter on all topics usually treated to be surprisingly great. Professor Willson has a gift for condensing without loss of clearness.

With this power, he does well to restate for convenient reference many of the fundamental definitions which he presumes already in some form previously mastered—for example, the definition of the trigonometric functions on p. 31.

But I still prefer the definition in the note on p. 121, "A straight line is the line which is completely determined by two points:" to the author's second thought given in the preface, "The line that is completely determined by any two of its points." The spheric space of non-Euclidean geometry, though movable as a whole in itself, is such that two geodetic lines in it always cut in two points.

Of course, no spherical trigonometry is employed in the author's solution of the problems of trihedrals, purely a graphic process, as it should be. We are glad to find as an appendix