The lectureship in chemical physiology is vacant by the resignation of Dr. A. Sheridan Lea, F. R. S., on account of ill health.

Prof. Bubnof, of Dorpat, will succeed Prof. Erismann in the chair of hygiene in the University of Moscow. Dr. S. Bianchi has been appointed full professor of anatomy at Vienna, and Dr. B. Boccardi associate professor of microscopical anatomy in the University at Naples.

DISCUSSION AND CORRESPONDENCE.

COMPARISON BETWEEN THE USE OF FIXED AND MOVABLE CIRCLES, IN THE DETERMINATION OF DECLINATIONS BY MERIDIAN CIRCLE.

One advantage claimed for the use of a movable circle is, that it tends to eliminate the effect of graduation errors.

This effect will not be entirely eliminated by any number of changes in the position of the circle; but considering it as one of the sources of accidental error, the mean of a large number of observations will be affected by the mean of the errors of graduation for the increased number of divisions.

The relation of this error, to that due to other conditions, should also be considered; and in establishing the advantage of using the movable circle, in so far as graduation errors are concerned, one should be confident that no other sources of error are introduced.

In dealing with instrumental errors it is undoubtedly sounder policy to arrange observations so that they may be eliminated, rather than to determine the effect of such errors and correct for them.

But this policy refers to errors that can be actually eliminated, and without introducing others of unknown character or amount. Where both methods may be used, actual elimination of error, and, its determination and subsequent correction, the advantage is recognized, in the knowledge thus gained of the general laws governing errors and their correction.

In the case of a fixed circle the instrument is a homogeneous one throughout a series of observations, which may extend over many years. The laws of flexure may be studied by consecutive determinations, as part of a united series; and, in general, the performance of the instrument can be investigated, under the varied conditions arising from extended use, with the certainty that some errors are truly systematic in character.

With a movable circle there is the advantage of variation of conditions, which may produce results nearer the truth, in the average, by absence of certain systematic errors.

It will always be a matter of judgment based upon experience, whether one can deal better with results affected by systematic errors, or with observations in which they are replaced by accidental ones.

In practical observing one method is usually adopted for general work. While there are other conditions that may determine which method will be used, a comparison of their respective accuracy is not without interest, using such material as may have a bearing upon such a test.

For the purposes of illustration the probable error of graduation, for the mean of four divisions, may be assumed to be $\pm$ 0″.15, the value obtained in the measurement of the 1° arcs, of the Repsold Meridian Circle of the Lick Observatory. If this error were entirely accidental, throughout, a reading made upon two adjoining divisions should have a smaller error; but as there appears to be evidence of a periodic character in the graduation, this value may be adopted for the present comparison.

Representing by g the *probable error* due to graduation, for the general case of a measure of zenith distance we should have to consider the error of the Nadir reading, and g would be $\pm$ 0″.21.

With a fixed circle, however, if the value of the latitude, used in determining star declinations, is that obtained by observations of standard stars with the same instrument, the graduation error of the Nadir reading is actually eliminated from the results. Or, if when the instrument is reversed the same divisions come under the microscopes at the Nadir reading, the graduation error of those divisions is then eliminated from the measurement of any particular zenith distance in both positions. Under these conditions, the probable error g of a determination of a star's declination, by means of reading on

the Nadir will be $\pm$ 0″.15 for one position, $\pm$ 0″.10 for both positions, quantities which will not be diminished by an increase in the number of observations.

In the use of a movable circle, since new divisions are brought under the microscopes for the Nadir reading, each measure of declination will be affected by the probable error g of $\pm$ 0″.21.

The mean of four observations would have the probable error g of $\pm$ 0″.10, whether made in one position of the instrument or in both, By increasing the number of observations the movable circle would gain in accuracy over the fixed circle, in so far as this source of error is concerned. Thus, for eight observations, four made in each position of the instrument, for the fixed circle g would be as before $\pm$ 0″.10, while for the movable circle g would be $\pm$ 0″.08.

For differential determinations of declination the result, in both cases, will be affected by the probable error of graduation for the mean of the stars used as standard. If eight fundamental stars are used, the probable error g of the mean would be $\pm$ 0″.05, and the probable error g in the resulting declination would be $\pm$ 0″.16, from one observation.

With the fixed circle in both positions of the instrument the declination would have g equal to $\pm$ 0″.11.

The movable circle would give g,
for two observations $\pm$ 0″.11,
for four observations $\pm$ 0″.08,
and for eight observations $\pm$ 0″.06.

The above treats of a movable circle shifted for each night of observation. The custom of changing the position at stated intervals will have an advantage, only, in bettering the determination of stars observed as standard over long periods.

In order to obtain a more complete comparison, it will be necessary to combine the effect of graduation error with the accidental error from other sources. The purely accidental error may be assumed to be $\pm$ 0″.25 for one observation, including that of the determination of the reference point, by either standard stars or nadir readings. While it may be smaller in some cases, this value can be used as a basis of comparison.

The probable errors of declinations, determined with fixed circle and with movable circle, by both methods, would be predicted as follows:

	Nadir.	Differential.
Fixed Circle:	//	//
One position, 2 observations.....	±0.23	±0.24
4 "	±0.19	±0.20
8 "	±0.17	±0.18
Fixed Circle:	//	//
1 observation in each position....	±0.20	±0.21
2 " " " "	±0.16	±0.17
4 " " " "	±0.13	±0.14
	//	//
Movable Circle: 2 observations....	±0.23	±0.21
4 "	±0.16	±0.15
8 "	±0.12	±0.11

With an increase in the number of observations the movable circle would gain slightly. But, on the whole, it is doubtful whether the gain is not more than compensated by the advantages of having a permanent relation between circle and telescope. Some of these advantages become apparent when old observations are to be discussed for light upon some of the refinements of investigation. This permanency and consistency give a definite basis to work upon, when treating methods or results.

As an individual illustration, since the usual method of determining telescope flexure includes the sine term of the circle flexure, this last does not need to be independently measured; the effect of both may be determined, and their laws studied together. With a movable circle the flexure would need separate treatment for each position.

This comparison has been suggested, in part, by a note in this JOURNAL, in which the preference for the movable circle is indicated; and the utility of the measurement of Division error is questioned. (H. J., SCIENCE, Jan. 31.)

The actual measurement of errors of graduation would, presumably, replace those errors by the probable uncertainty of the measurement. With the method employed for this instrument, the probable error of the measurement of the 1° arcs is less than $\pm$ 0.″04.

Since each division may be measured, as has been done thus far, from two others, the probable error can be kept within small limits by making a sufficiently large number of measures. Practi-

cally it would probably increase as the subdivision of arcs is carried on. There are some statements in the note referred to, which appear to be misleading. To quote:

"Even if the division error of any given line could be determined with complete precision with the telescope pointed at the zenith, this division error would not hold true when the telescope is pointed elsewhere. Nor is this brought about by flexure alone. It is found that if we determine the division errors of a straight scale, these errors are completely changed when the scale is reversed end for end. No doubt unavoidable difference in the illumination and the eye of the observer are responsible for these unfortunate facts. But facts they are, and the cause of much wasted labor."

While the measurement of the division errors of a straight scale might not hold true if the scale were reversed end for end, this apparently damaging condition has nothing whatever to do with the measurement of the division errors of such a divided circle, since it cannot possibly be reversed; but is always read, facing it, in the same position.

As the instrument is moved to various settings, any single division passes under the various microscopes, and is read at various inclinations to the vertical, under various conditions of illumination, and to make the illustration as wide as possible, by various observers. The reading at any microscope will be affected by all the conditions of phase of that microscope, and by the personal equation of the observer, which may be, and probably is, peculiar to that microscope.

But there is no reason that these conditions should differ for the various divisions, which come in succession under the same microscope, or set of microscopes. In every case of star observation, or of determination of graduation error, the difference is measured between a reading of the circle at the required setting, and some standard reading.

Personal equation and phase should affect each reading alike, and should be eliminated from the results.

As to the effects of differences in the illumination and the eye of the observer, if they exist, they must be equally injurious to all observation with this instrument, as, in fact, they must be in every class of observing. Such sources of error fall within the class admitted as accidental; with proper care and well designed illumination, they are not believed to be large enough to invalidate the results obtained with fine instruments in astronomy of precision.

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SCIENTIFIC LITERATURE.

Elements of Geology, a text-book for colleges and for the general reader. By Joseph Le Conte. Fourth edition, revised and enlarged, with new plates and illustrations. New York, D. Appleton & Co. 1896.

For nearly twenty years Le Conte's Elements of Geology has stood side by side with Dana's Manual in the working libraries of American geologists and teachers. It has found equal favor in the class-room and the study room, and has been widely read by the cultured layman. Holding this enviable position, it needs neither introduction, encomium nor criticism; but the appearance of a new edition may rather serve as an occasion to enquire what are the qualities on which its success depends.

I conceive that one of the first of these is a wise choice of material. The author is fortunate in possessing the power to select the more essential and ignore the less essential, so that the principles he expounds are not obscured by clouds of detail. Moreover, he devotes all his space to his proper theme, the science of geology, assuming, on one hand, that the reader has all necessary knowledge of physics, chemistry, astronomy, meteorology, biology, and even mineralogy, and not undertaking, on the other, to teach him either the technology of the professional geologist or the economic application of geologic results.

Of equal importance, perhaps, is the order of presentation, which deviates somewhat from the strictest system so that it may follow lines of least resistance. One who writes on a complex subject is always embarrassed by the fact that the easy explanation of each part seems to require the previous explanation of some other part; and in geology this contest for priority lies between processes of change and the struc-