

IV.—*Further Remarks on Tolles' $\frac{1}{8}$ th and Powell and Lealand's Immersion $\frac{1}{16}$ th.*

By EDWIN BICKNELL, Cambridge, Mass.

ON page 225, vol. vi., of the 'Monthly Microscopical Journal,' I made some "Remarks" on Dr. Woodward's "Note" in the number for September preceding. In the number for January, 1872, vol. vii., page 28, Dr. Woodward says that I have "wilfully" misinterpreted his *published measurements* of the wet front of the Powell and Lealand $\frac{1}{16}$ th. I have *not* misinterpreted the *actual power* of the above-mentioned objective, although Dr. Woodward's published measurements may look so exact—on paper; and in order to make out my case I shall not go beyond Dr. Woodward's own statements and "published" work, except in one case, to obtain my evidence.

On page 29, vol. vii., Dr. Woodward gives a table of measurements of different objectives from Powell and Lealand, both wet and dry: I wish to state here that I have nothing to say in regard to any of the *dry fronts*, and only with regard to *one* immersion $\frac{1}{16}$ th, and that one is No. 2. I assume this to be the one from the magnifying power as given in the table agreeing with Dr. W.'s *published measurements*.

Dr. Woodward quotes from Mr. Charles Stodder* that "objectives are named when adjusted for uncovered objects, a fact not generally known by purchasers. The power increases, that is, the focus is shorter as the collar is turned to work through the covering glass." This is the method which I have used during the past two years, and I consider it the most certain and reliable.

During the past winter Mr. Stodder has loaned me the glass positives of *Amphipleura pellucida*, which were made at the Army Medical Museum, with the Tolles' $\frac{1}{8}$ th described by Dr. W. in his "Note," and also the positive made with the Powell and Lealand $\frac{1}{16}$ th at the same time. These positives are marked precisely like those described by Dr. W. in his "Note," and are probably duplicates of those sent to the Editor of this Journal by Dr. Woodward. I have carefully and repeatedly counted the lines in the positive made by the Tolles' $\frac{1}{8}$ th (without eye-piece at 48 inches distance from the object to the screen). The length counted is exactly $\frac{1}{8}$ th of an inch (the reason of this will be seen farther on), and in this space I find just 74 (seventy-four) lines, making 370 lines to the inch in the positive. Dr. Woodward gives the fineness of the lines on the *Am. pellucida* at 95,000 to the inch. Dividing 95,000 by 370 gives 256+ diameters as the power of the objective at 48 inches distance, which is just what Dr. W. has marked the positive. 48 divided by 256 gives .1875, making the objective at that position of

* 'M. M. J.,' Oct. 1871, p. 203, note.

cover adjustment a little less than $\frac{1}{3}$ th of an inch in equivalent focal length, that is, of higher power.

Now, on counting precisely the *same* portion of the *same* frustule in the positive made with the Powell and Lealand objective (the portion here counted being one *inch* long, whereas in the other it was one-fifth, but in both cases exactly the same portion), I find just 75 lines (seventy-five lines) to the inch. 95,000 divided by 75 gives 1266+ diameters at 48 inches distance. 48 divided by 1266 gives .0387+, making the objective at this point of the cover adjustment a little less than a $\frac{1}{25}$ th of an inch in equivalent focal length. It will be seen that this differs materially from Dr. Woodward's "published measurements." He gives in his table on page 29, vol. vii., 1100 diameters at full correction for thickest cover at 48 inches distance (yet on the glass positive which I have counted he has marked 1140 *diam*). I make it 1266+ diam. Let us reverse the process, take the Doctor's "published measurements," 1100 diam., and multiply it by 75, the number of lines to the inch in the positive; this will give 82,500 as the fineness of the lines on the *Am. pellucida* which he has photographed (1140 diam. will give 85,500), quite a falling off from his 95,000. If the "published measurements" are right, the *Am. pellucida* is not 95,000 to the inch.

It will be seen that instead of being about three times the power of the Tolles' $\frac{1}{3}$ th, which Dr. W. has called a little higher than a $\frac{1}{3}$ th—and my count of the photograph agrees closely with his statement—the Powell and Lealand objective is *five times* (very nearly) *the power*. This increase of fifty per cent. over the nominal power cannot be altogether ascribed to the cover adjustment, as Dr. W. in his table above quoted gives the entire range at less than twenty per cent. In fact, the objective is at least a $\frac{1}{9}$ th at its uncovered point, and this *was known to Dr. Woodward* before he made the comparison with the Tolles' $\frac{1}{3}$ th, with the disparaging assertion that "the new $\frac{1}{3}$ th cannot be claimed to supersede the highest powers now in use, yet nevertheless is not, in my opinion, injurious to the $\frac{1}{3}$ th." Mr. Charles Stodder writes, with good authority, probably under the date July 20th, 1871 (this was nearly two months before I saw Dr. Woodward's "Note"), "He has now ascertained that the Powell and Lealand so-called $\frac{1}{3}$ th objectives are really $\frac{1}{9}$ th; the so-called $\frac{1}{16}$ th is a $\frac{1}{15}$ th."* This did not reach this country until after my "Remarks" had been sent to this Journal, and I knew nothing of Mr. Stodder's communication until I saw it in print, and he knew nothing of mine until he saw it in print.

In the number of this Journal for April, 1872, page 166, Dr. Woodward alludes to a so-called $\frac{1}{30}$ th by Wm. Wales, and after, "a determination of its magnifying power, however, shows that un-

* See 'M. M. J.' vol. vi., p. 203.

covered it magnifies rather less, at covered rather more, than the Powell and Lealand $\frac{1}{8}$ th." Further, "its equivalent focal length at uncovered is therefore $\frac{1}{8}$ th, very nearly." The same is repeated in the 'American Naturalist' for April, 1872. Why does Dr. Woodward still persist in calling an objective a $\frac{1}{8}$ th, which he has repeatedly admitted to be higher than a $\frac{1}{8}$ th, and which Mr. Charles Stodder writes he has "ascertained to be a $\frac{1}{9}$ th"? On page 30, vol. vii., of this Journal, Dr. Woodward has published a table of powers in decimals of an English inch. In this table he gives the *dry* Powell and Lealand $\frac{1}{8}$ th at uncovered point the expression $\cdot 0623$. That is all right as far as the dry front is concerned, but if the reader wishes to know the power of the immersion front at its lowest power he may substitute the decimal $\cdot 0533$, and he will be not far from right.

I can still furnish further evidence to prove my position, but do not think it at all necessary. The members of the Royal Microscopical Society can count the lines in the glass positives, which I believe they have duplicates of, and satisfy themselves of the truth or otherwise of my statements. I counted the lines with a low power, 4-inch, and positive eye-piece, and was very careful to count the same part of the same frustule in both cases.

Dr. Woodward brought out his tables in "fair play" to Messrs. Powell and Lealand, and undertook to show that the objective was *not* of higher power than its denomination. I write this communication in order to show that the immersion front made it of *much higher power*, and those makers whose objectives are correctly marked, or nearly so, would not have "fair play" if their work was tested against this objective and its actual power not stated.

V.—On Uniformity of Nomenclature in regard to Microscopical Objectives and Oculars. By R. H. WARD, M.D.

THE *nominal focal length* of an achromatic objective, as used by microscopists generally, represents its amplifying power as actually used in the compound microscope. Even the equivalency in amplifying power with a single lens of the same focus is no longer distinctly realized, while the size and appearance of the combination, its working focus, angular aperture, and microscopical efficiency, are not even hinted by the figures used. The nominal focus represents the magnifying power and those properties dependent on it. Like other measurements, these must be stated by comparison with known standards. To use diverse and unknown units of measurement in cases designed to be compared with each other is simply