stereoscope as he writes part of the time, then the vertical exaggeration is increased by a factor of 1.25. For Example 1, this would make the $E_v$ equal to 1.0; it would be 1.5 for Example 2; and 1.7 for Example 3. Only in Example 3 does Goodale's value get much above 1. If the correct interpretation was given to his symbolism, his formula is unsatisfactory both from the standpoint of application and of theory.

Thurrell's method was difficult to derive experimentally; but once he has reduced the findings to a graphical representation, it is very easy to apply and the results seem reasonable. For the two examples using 8.25″ focal length, and to which Stone's method applies, Thurrell's value lay between those of Stone and Treece. The only difficulty with his method is the application of the correction factors which he mentions. In the values given above, no correction factors were applied.

Stone's formula is very limited in the type of photography for which it is recommended, and even for that type the vertical exaggeration values appear to be on the low side, but not enough to make a great difference in the value obtained for the angle of slope in most cases. It is highly recommended though that he give his formula as a constant times the ratio of $b/b_e$ instead of giving an incorrect impression of the effect of the stereoscope and camera focal lengths. If the findings of this paper are correct, he also needs to revise that constant upward to give a more true value.

The values found by the formula derived in this paper were the highest of any found for all three examples. This may or may not indicate something defective with it. The author thinks not. His own limited experience with estimating angles with a stereoscope, and then measuring them in the field, is that the estimation usually is too high. A larger vertical exaggeration factor would tend to correct the error. The fact still remains that the most difficult part of measuring slope with a stereoscope is the estimation of the angle of slope as it appears under the stereoscope.

Others are invited to test the results obtained by using the various methods described. The photo-interpreter is urged, however, to estimate the angles as they actually appear without making any kind of a mental correction to make them what he thinks that they ought to be. The results should then be field-tested. It is hoped that some one will report on the comparison of the methods as tested in the field.

### Bibliography

Aschenbrenner, Claus M., "A Review of Facts and Terms Concerning the Stereoscopic Effect," Photogrammetric Engineering, Dec., 1952, pp. 818–823.

Goodale, E. R., "An Equation for Approximating the Vertical Exaggeration Ratios of a Stereographic View," Photogrammetric Engineering, Vol. XIX, Sept., 1953, pp. 579–588.

Miller, Victor C., "Rapid Dip Estimation in Photo-Geological Reconnaissance," *Bulletin American Association of Petroleum Geologists*, Vol. 34, No. 8 (Aug., 1950).

Miller, Victor C., "Some Factors Causing Vertical Exaggeration and Slope Distortion on Aerial Photographs," Photogrammetric Engineering, Vol. XIX, Sept., 1953, pp. 592–607.

Stone, Kirk H., "Geographical Air-Photo-Interpretation," Photogrammetric Engineering, Vol. XVII, Dec., 1951, pp. 754–759.

Thurrell, Robert F., Jr., "Vertical Exaggeration in Stereoscopic Models," Photogrammetric Engineering, Vol. XIX, Sept., 1953, pp. 607–616.

## DISCUSSION OF PAPER BY WALTER A. TREECE

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MR. TREECE's paper is interesting and most welcome. There is little doubt that it will promote renewed discussion of a subject which requires and surely deserves more profound and thoughtful study. In my opinion, we have had enough theorizing. What is needed now are good, sound experimentation and *proofs*.

In this respect I find Mr. Treece's paper lacking. There are two drawings given to illustrate geometrical relationships, one of which is admittedly copied from another paper, the other smacks of the pen of Wheatstone, who offered his concept of stereoscopy to the world more than 100 years ago.

Like Treece, Wheatstone also based his theory on a virtual image. Today, however, most photogrammetrists recognize that stereoscopic perception is affected by many factors, among which are two variables which greatly alter the impression of relative height. These are the viewing distance ($fs$) and print separation ($S$). To the former, Mr. Treece pays tribute; the print separation ($S$) factor, however, is conspicuously lacking in his formula.

Surely, any mathematical formula which cannot be applied to all cases is inadequate. In fact, it is less desirable than a qualitative study, because it is limited in scope, misleading and clumsy. Thus, after boldly presenting a "mathematical" solution to the hopeful reader, Mr. Treece dashes his hopes to the ground by warning that the equation must not be applied to other than lens stereoscopes (mirror-type excluded).

Except for the minor difference of viewing distance versus stereoscope focal length, Mr. Treece apparently accepts my "assumptions" and geometry as correct up to the point of determining the distance "$N_s$," which locates the stereoscopic datum plane. Therefore, at that point, the logical procedure would seem to be to attempt to prove a value for the proportionality constant "$K$," thus proving the writer's formula to be either correct or incorrect. For reasons of his own, Mr. Treece makes no attempt to do this. Instead he chooses to freeze the plane of stereo-fusion at one level for each stereoscope. At another point in his paper, however, Mr. Treece recommends a greater or lesser amount of print separation to compensate for height differences. Is this an admission that there is more than one plane of stereoscopic fusion per stereoscope?

For my money, the key to the problem is in proving where the "planes of stereoscopic fusion" are located. Perhaps one day soon, I shall take the time to work on it.