per cent, respectively. The speed of reading was much less for the print on gray paper. However, in order to emphasize the difference in the shapes of the two curves, they have been arbitrarily crossed at 4 footcandles. The speed of reading the high-contrast reading matter does not increase appreciably beyond about 16 footcandles, but there is no indication of an optimum speed of reading for the low-contrast reading matter in the same range of footcandles. When the illumination was increased from 4 to 20 footcandles, the rate of reading the low-contrast material increased almost 60 per cent, whereas the rate for the high-contrast material increased only 17 per cent.

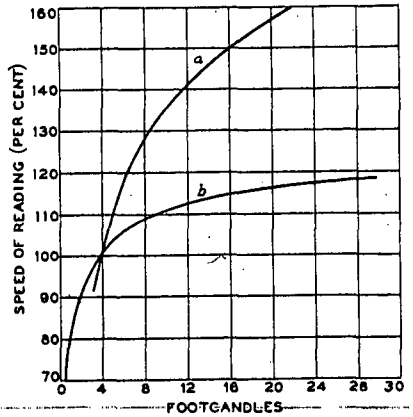

Figure 4. Speed of reading depends upon the contrast between the ink and the paper. *Curve b is for* black print on white paper and curve *a* is for black print on gray paper. The two curves have been arbitrarily represented as 100 at 4 footcandles to show the relatively greater increase in speed for the more difficult task, *a*.

The limited available data on a number of typical workworld tasks show that higher levels of illumination are significantly effective in improving speed and accuracy of working.[13–16] For example, the speed of reading a steel vernier rule to .001 inch continued to increase up to 200 footcandles with no indication that an optimum had been reached. The speed of discrimination of small brass-on-steel and steel-on-brass objects increased with levels of illumination up to 100 foot-

[13] C. E. Feree and G. Rand, Intensity of light and speed of vision with special reference to industrial situations, Parts I and II, *Trans. Illum. Eng. Soc.*, **22**, 79 (1927), and 23, 707 (1928).

[14] M. Luckiesh and F. K. Moss, Light, vision and seeing, *Ind. Med.*, **7**, 636 (1938).

[15] Lighting for woolen and worsted textile mills (Report of Joint I.E.S.-A.S.M.E. Committee on Lighting in the Textile Industry), *Illum. Eng.*, **44**, 364 (1949).

[16] H. R. Blackwell, *Illum. Eng.*, **47**, 605–606 (1952).

candles (the maximum available) with no leveling off. In other words, when difficult, small, low-contrast tasks are involved, several hundred footcandles are required for optimum visual performance.

Visual acuity and speed of reading can be considered as indicators of precision of seeing and production, respectively. Ideally, if all workworld tasks could be studied in the laboratory, it would be possible to determine the footcandle level that will permit the worker to achieve optimum performance. That is, curves such as shown in Figures 2 and 4 could be obtained for each task. Since this is impracticable, it is necessary to devise a method by which typical tasks can be visually appraised and related to fundamental laboratory data.

The unaided human being cannot make accurate measurements. All he can do is judge qualitatively that things are hot or cold, soft or hard, and so forth. Instruments and measuring techniques are necessary. An instrument that has been found to be extremely useful is the Luckiesh-Moss Visibility Meter,[17–19] illustrated in Figure 5. Variable density filters are used to reduce a visual task to the thresh-

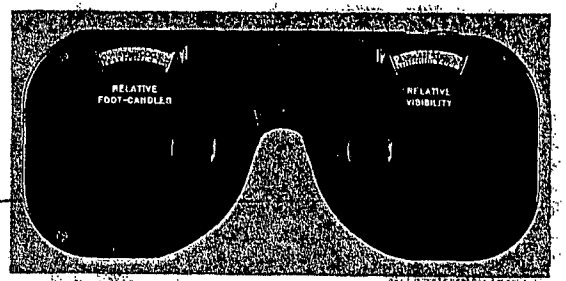

Figure 5. The portable Luckiesh-Moss Visibility Meter. This is a useful instrument for determining footcandles for equal visibility.

old of perception and, by means of an appropriate scale, the required filter density is assigned a numerical visibility rating. With this instrument, the visibility level of a task is related to the visibility of standard laboratory test objects viewed under specified conditions. Recent data have shown that these visibility ratings are directly relatable to the absolute threshold of illumination[20] and to the brightness-difference threshold.[21]

[17] M. Luckiesh and F. K. Moss, Visibility—its measurement and significance in seeing, *Franklin Inst.*, **220**, 431 (1935).

[18] M. Luckiesh, A. A. Eastman, and S. K. Guth, Technique of using the Luckiesh-Moss Visibility Meter, *Illum. Eng.*, **43**, 223 (1948).

[19] S. K. Guth, Visibility, *Gen. Elec. Rev.*, **55**, 26 (1952).

[20] M. Luckiesh, S. K. Guth, and A. A. Eastman, A new scale of relative footcandles for the Luckiesh-Moss Visibility Meter, *Illum. Eng.*, **45**, 211 (1950).

[21] S. K. Guth, A. A. Eastman, and R. C. Rodgers, Brightness difference—a basic factor in seeing, *Illum. Eng.*, **48**, 233 (1953).