Considerable research has provided us with comprehensive data on the rela
tionships among these four fundamental factors.[6-9] Figure 2 illustrates how con
trast and size vary for three brightness levels. The curves represent the borderline
between visibility and invisibility. Small objects must have high contrasts in orde
to be seen and, conversely, low-contrast objects must be relatively large in size
As the brightness level is increased, either the size or the contrast, or both, may
be decreased. Similarly, when considerable time is available for seeing, objects
can be small in size or low in contrast. However, in the case of many typical

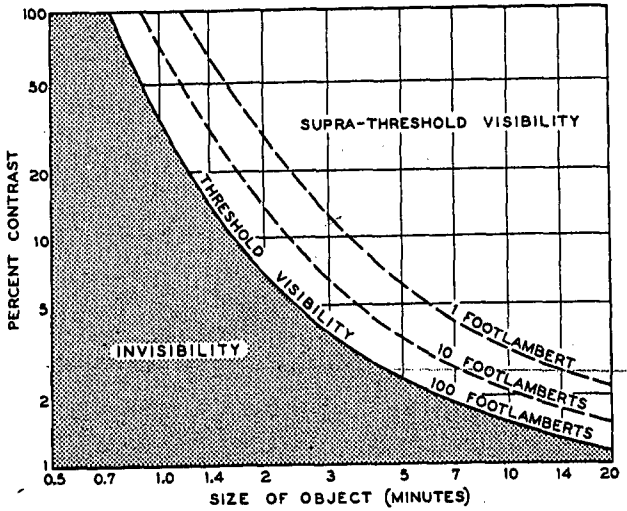

Figure 2. The relationships among size, contrast, and brightness. The invisible region shrinks as the brightness level is increased.

visual tasks, size, contrast, and time are generally fixed. Therefore, it is apparent that the most universally controllable factor is brightness.[10] Increased brightness is obtained by higher footcandle levels.

A familiar method of presenting data on the effectiveness of illumination is in

[6] H. R. Blackwell, Brightness discrimination data for the specification of quantity of illumination, *Illum. Eng.*, **47**, 602 (1952).

[7] H. C. Weston, *The Relation between Illumination and Visual Efficiency—The Effect of Size*, Joint Report on Industrial Health Board and Illumination Research Committee, Report No. 47-105, H. M. Stationery Office, 1935.

[8] H. C. Weston, *The Relation between Illumination and Visual Efficiency—The Effect of Brightness Contrast*, Medical Research Council, Industrial Health Research Board, Report No. 87, H. M. Stationery Office, 1945.

[9] M. Luckiesh, *Light, Vision and Seeing*. Van Nostrand, New York, 1944.

terms of visual acuity, or the ability to distinguish fine details. Some typical results are shown in Figure 3 for black objects viewed against white and gray backgrounds.[11] The relative visual acuity obtained with a black-on-white test object and 10 footcandles is assigned the value of 100 per cent. However, it must be remembered that the majority of industrial tasks are not black on white, but range from light gray-on-white to dark gray-on-black. Thus, the right side of Figure 3

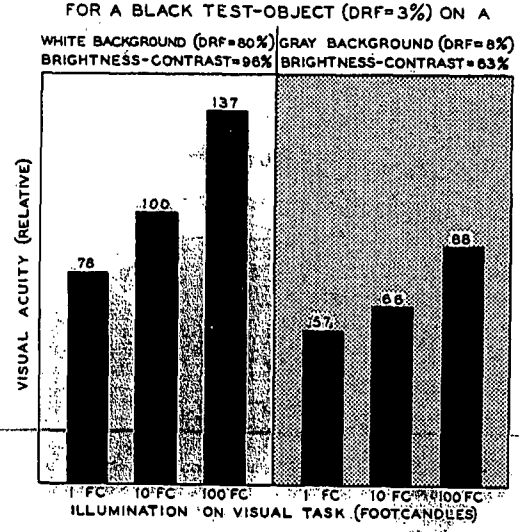

Figure 3. The contrast between an object and its immediate background is an important, but often neglected, factor in visual acuity. For a given footcandle level, visual acuity is considerably less when the contrast is low (DRF = diffuse reflection factor).

is particularly significant. With 10 footcandles, if the contrast is decreased from 96 to 63 per cent, visual acuity is reduced about 34 per cent. In other words, for a given footcandle level a larger object is required for lower contrasts. Even with 100 footcandles, the relative visual acuity with the lower-contrast test object is 12 per cent less than that obtained with 10 footcandles on a black and white task. Thus, if visual acuity is to be used as a basis for prescribing illumination, it is necessary to have data for a wide variety of contrasts.

Similar results are obtained when speed of reading is the criterion. In Figure 4 are presented data obtained while reading black-on-white (curve *b*) and black-on-gray (curve *a*) printed material.[12] The reflectances of the papers were 80 and 23

[11] M. Luckiesh, Visual acuity and visual tasks, *Illum. Eng.*, **39**, 415 (1944).

[12] M. Luckiesh, A. H. Taylor, and R. H. Sinden, Data pertaining to visual discrimination and desired illumination intensities, *J. Franklin Inst.*, **192**, 757 (1921).