

Later Lowell⁴ tried out a similar experiment with the result of finding his wire visible easily at 0".89, with some difficulty at 0".83 and glimpsed down to 0".69. Evidently his contrast conditions were less good than Barnard's. A further test by Slipher and Lamp-land⁵ showed the wire disappearing from certain vision at 0".86, while a dark blue line on a white disk held down to 0".83. W. H. Pickering⁶ experimenting with a dark human hair against open sky found it easily visible when subtending an angle of 1".13, easily glimpsed at 0".97, occasionally glimpsed at 0".83, and quite invisible at 0".72.

Taking up the converse case the writer first tried a German silver wire 0.01 inch diameter stretched zigzag in lengths of several feet over a dark plank bulkhead. The reflectivity of this varied from about 0.06 to 0.12, *i. e.*, a very dark gray. The test was in full sunshine and the observers, the place being the range of the Massachusetts Rifle Association, were a group of riflemen, keen of sight and experienced in close observation. The terrain was laid off in 50-foot spaces and the results were as follows: Wire vanished across lighter parts of background at 75 feet (2".3) while across the darkest of that background the wire persisted up to 200–250 feet, beyond which it was invisible save for specular glints especially at twists. To summarize:

Angular Diameter	Appearance
1".11.	Parts against dark background were plain.
0".86.	Portions seem distinctly but not steadily.
0".69.	Visible at specular spots, difficultly glimpsed elsewhere.
0".46.	Visible by specular reflection only.

A second test with some of the same observers was made, using a background of black paper (coefficient .045), white thread 0.008 inch in diameter, and drawn tungsten wire 0.005 diameter. The paper was nailed to the former bulkhead and wire and thread stretched zigzag as before. Observed in bright skylight, also in moderately bright sunshine. The wire was visible with difficulty to one

observer at 150 feet and beyond this disappeared utterly. To the others it could be fairly made out only at 100 feet. The thread, which was much brighter than the wire, began to be lost in parts at 200 feet, but in sunshine held rather indistinctly but unmistakably to 300 feet. When the sun went in the thread was lost at about 200 feet. To summarize again

Angular Diameter	Appearance
Wire 0".86.....	Limit for all but one observer.
0".57.....	Fairly seen by one observer.
Thread 0".92.....	Network distinct all over.
0".69.....	Parts distinct in sunshine.
0".55.....	Parts evident in sunshine.
0".46.....	Near limit of visibility. Only small bits of network seen.

In the case of the thread the brightness contrast between thread and background was about 16:1. With brilliant sunshine and a background of even deader black there might have been a slight further gain, but we were evidently close to the limit. It is rather noteworthy that there should be so near an agreement throughout as between dark on bright and bright on dark, but barring specular direct reflection the brightness contrast which determines visibility is not widely different in the two cases, and the *minimum visibile* for a linear object with strongly contrasted background would appear to be about 0".5 ±. It is certainly less than 1/50 the *minimum visibile* for a round spot giving similar contrast, a remarkable evidence of the efficient coordination of retinal impressions.

BOSTON

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SCIENCE

A Weekly Journal devoted to the Advancement of
Science, publishing the official notices and pro-
ceedings of the American Association for
the Advancement of Science

Published every Friday by

THE SCIENCE PRESS

LANCASTER, PA.

GARRISON, N. Y.

NEW YORK, N. Y.

Entered in the post-office at Lancaster, Pa., as second class matter

⁴ *Bulletin Lowell Obs.*, No. 2.

⁵ *Lowell Obs. Bull.* No. 10.

⁶ *Pop. Ast.*, 23, 578.