

for. In my third and last notice (iii. 143) the manner in which the muscles attached to the occipital style are inserted was alluded to, and it was compared with an ossified ligamentum nuchal. All of this I still maintain. At that time, for lack of material, I had not especially looked into its physiology; and my discussion with Mr. Jeffries closed (Feb. 8, 1884). Since, both through my reading and observation, much has come to my notice of interest with regard to it. Garrod's dissections of *Plotus anhingia* are very suggestive. Dr. Gill had kindly called my attention to Yarrell's paper, before his notice in *Science* appeared, which he had unexpectedly come across while searching for facts to illustrate another subject. Finally, in one of the most useful and reliable of books, Coues' 'Ornithological bibliography,' I had noticed Rudolphi's article; but other matters were engaging my attention then, and reference was not made to it. There are still others. I have already cited Eytton's figure (iii. 143), and believe, at the time Dr. Gill's review of my work appeared, I was hardly entitled to the charge he brings against me in it. I am more and more convinced, every day of my life, that *good illustrations* of such common facts in anatomy are most urgently demanded. R. W. SHUFELDT.

A singular optical phenomenon.

I think it would well repay almost any one to study the beautiful phenomenon so clearly described by 'F. J. S.' (*Science*, No. 57, p. 275), and so suggestively discussed by Professor LeConte (No. 61, p. 404). My own theory of it involves no inverting action, as in the camera, and no *primary* dependence upon binocular vision, but, rather, it resembles the theory of watered silks, or of chords and beats in music. It seems to me geometrically demonstrable; and it includes the phantom meshes' gigantic size, their bewildering motions, their conspicuousness even to eyes out of focus for the actual wires, and the non-appearance in them of objects attached to those wires.

Before the observer are two parallel screens of square-meshed wire netting. The coarser one is seen through the finer, and the two are at distances from him nearly proportional to the diameters of their meshes, measured from centre to centre of the wires. To fix the ideas, suppose that he looks with only one eye, seeing the nearer wires black and the farther ones bright; then, if the above proportionality be exact, all the bright wires can be simultaneously eclipsed, each by a separate dark wire; or, upon moving the eye very slightly to the right and upward, all the bright wires will flash into view at once. Now let the observer advance or retire a few inches from this first position, so that the dark wires may subtend visual angles a little larger or smaller than do the corresponding bright ones: several successive bright wires will thus be in view, then one or more will be eclipsed, then several others will be seen, and so on; that is, the phantom screen will be formed, with its great square meshes and shadowy bars.

Next let the observer move slightly to the right: the phantom also moves, but more, and to the right or the left, according as he is in front of or behind his first position. Indeed, the motions of the phantom bars, and the visual angles they subtend, are as if the observer viewed a virtual image whose plane passed through his first position, but imagined it to be some feet in front of him. The size of the virtual image would be very nearly such, that, in it and the farther screen together, there would be as many bars to the foot as in the nearer screen. Its colors would appear

to be those of the farther screen, but weaker and oppositely arranged. It would *not* be upside down. Indeed, if 'F. J. S.' will paint the upper wires of the farther screen vermilion, or will hang behind them a blue curtain, then I think that the upper meshes, but not the bars, of the phantom, will be reddened; or the upper bars, and more slightly the meshes, of the phantom, will be bluish. Or, if he will paint the vertical wires red and the horizontal wires yellow, probably the phantom meshes will incline to orange, the vertical phantom bars to yellow, and the horizontal ones to red.

Suppose that two-thirds of the light coming from within the boundary of the farther screen be from the bright wires: then the phantom meshes will be three times as bright as the phantom bars; but at their edges they may blend into one another, the eclipses there being less complete. Thus no lines appear in the phantom whose pictures on the retina are not much broader than the picture of a point, even when out of focus, and hence the phantom is seen by near-sighted and far-sighted alike.

Phantoms often less simple and conspicuous may be got when the visual angles subtended by single spaces in the two screens are not approximately equal, but are approximately in a simple numerical ratio. The screens may also be of lattice-work, or pale fences, not necessarily parallel, seen two or three deep against the sky; and the effects are sometimes very beautiful.

Undoubtedly, when the screens are fine, binocular vision, with the stereoscopic matching of patterns, comes in, as suggested by Professor LeConte; making the phantom seem real and solid, and fixing its assumed distance from the observer. But I leave this part of the discussion to him, because he can treat it far better than I can. JAMES EDWARD OLIVER.

Cornell university, April 8.

I was gratified to find that the phenomenon described in No. 57 proved of interest to Professor Joseph LeConte. He states that my explanation of the cause of the phenomenon is erroneous, and I am in no wise qualified to dispute him. Nevertheless, a careful repetition of the experiment would indicate that his explanation is not the correct one. The phantom image is as readily seen with one eye as with two; and I still think I am correct in saying it is inverted and magnified. I hope Professor LeConte will make the experiment himself, and give us his explanation of the phenomenon. In the mean time, allow me to state the facts as they occurred in an experiment made after reading his letter.

Standing about twelve feet from an ordinary fly-screen, and looking through it at the blinds of a house about one hundred and fifty feet distant, phantom lines, alternately a light one and a dark one, are seen crossing so much of the field of view in which the blinds lie, but not continued beyond their limits. The lines remain visible, although one eye be closed.

The image rises as I bow my head, and sinks as I lift it. Is not this evidence of inversion?

I can readily count the lines that lie across a blind, twelve light and twelve dark ones; but, in order to correctly count the actual slats in the blind, I am obliged, on account of the distance, to have recourse to a telescope. My wife, who is short-sighted, can only distinguish the mere outline of the actual blind; but the phantom lines are plainly visible to her. The number of slats in a blind is thirty, which would give sixty alternating dark and light lines. Is not this evidence of magnification? F. J. S.