

sized match and confusion colors of bunting for daylight work, or illuminated plates and lanterns of transmitted color for bad weather or night, are to be lined in a row in any order whatsoever, just as the wools are promiscuously thrown upon a table. The five test colors similar to the ones I have employed for the near tests are placed in an upper tier. Just as with the near-work tests the candidate employs one eye at a time. This done, he is then made successively to designate by the actual position of the color in the lower line the nearest numerical match to each of the upper test colors. This selection by number is to be handed to the examiner, who after having obtained the true color names of the numbers chosen for the occasion by the attendant, places the choosings upon suitable blanks for permanent registry.

To obtain the different percentages of light stimulus and to simulate as nearly as possible changes in character of weather (fog, rain, etc.), variously tinted glasses can be used, although preferably the candidate can by this plan be tested during the actual states of weather.

An experimental track with a number of open switches so arranged that the sidings pass directly beneath certain colors would be useful for practically testing the color vision that is necessary to employ while running locomotives, trolley cars, etc., at full and even high rates of speed.

In marine service the danger is increased. All vessels carry a green light on the starboard side, and a red light on the port, each being so boxed as to be seen forward and amidships. These are accompanied by a low white forelight, and sometimes by a high white aftlight. Hence, by comparison, a vessel's course can be easily distinguished. If, under such conditions, however, a heavy fog, or snow, or a rainstorm were to exist, it can be understood how an official with subnormal color perception, judging these important color distinctions by their intensities alone during the best of weather, is placed in a position that practically amounts to the absence of signals.

For the detection of the defect in marine and naval work, quite simple modifications and adaptations of color testing by which adequate data may be obtained can be made.

In all railway or marine testing, care must be taken that both the test and the later working colors* should be graded in proportionate sizes and relative intensities of tone, thus giving similar distance values to every color used in the tests. That this should be done will be at once appreciated when it is remembered that different degrees of vividness of color areas of equal size produce such alterations in impressions that the colors give rise to false perceptions regarding their relative distances from one another.

Again, the dominant colors of the reflecting surface near which the test is made (as, for instance, the green of a hillside, the gray and white of a mountain top, and the blue of an ocean surface) all play important rôles as to the value of the tests.

The character of the illuminant itself is of the greatest importance. The blue of diffuse daylight, the greenish or nearly white tint of incandescent zirconia or metallic oxide mantles, the varying degrees of yellow rays from oils, illuminating gas and carbon loops, and the purples of free arcs of electricity, show how variable in tint color areas must become when exposed to these different agents.

Endeavors should be made to try to overcome the totally different values that are empirically placed upon the hues of the test colors themselves. This might be done by assuming pigment hues which are equivalent, with the midway bands in the corresponding portions of the solar spectrum. Such selections could be determined mathematically and analytically by an international commission, and reproduced in pigments from a consensus of examination by national or sectional sub-committees of

* Unfortunately, it has been found by repeated experiment that the very colors which are the earliest and the easiest lost are the ones that must be used for practical purposes.

competent observers possessing normal color vision.* These pigments could then be used for signal boards, signal lights, and test colors in any given locality.

There should not be any degree of standard in regard to the color capacity of any railway or marine official whose routine duty consists in the differentiation of color. Such positions are relatively so few when compared with the great supply of available candidates, and the responsibilities are so grave, that no exception should be made. Such candidates should be rejected without a particle of sentiment.

The lack of systematic and periodic re-examination of the color sense is another great evil. This inefficiency in color testing is most reprehensible. After every case of severe injury or attack of illness that might in any way be likely to produce visual disturbance, an examination should be made; and, moreover, among those who are known by strict, and yet silent surveillance, to use any toxic agents, such as tobacco and alcohol, the tests should be both painstakingly and frequently tried.

The increased responsibility acquired by civil service, in which older subjects who are more prone to exhibit acquired color defects than younger ones, and who are at times given positions that usually necessitate the greater employment of normal color organs than before, should be especially subjected to careful periodic repetitions of some of the more important measures which are employed for the determination of the amount and degree of the color sense.

Losses of color in the so-called visual fields are quite common. They assume many forms, and quite frequently are expressive of definite types of both local and general disease.

Symptomatic in character, they oftentimes help demonstrate the exact position of intracranial disturbance, prove the actual functioning condition of inflamed and degenerating local tissues, give answer to situations of gross orbital change, and serve to distinguish functional complaint from organic disorder.

They are obtained in various ways: first, by ruled blackboards upon which small colored objects are carried toward central fixing points; second, by perimeters, which are mere mechanical contrivances for carrying small areas of color inward upon graduated metallic arcs toward fixed central points; and third, by similar movements of the outstretched fingers, lighted tapers, and focussing mirrors.

To be strictly accurate they should be repeated under varying conditions of time, luminosity, distance, and position.

Charles A. Oliver.

COLOR PERCEPTION, SUBNORMAL; RAILWAY AND MARINE EXAMINATIONS.—The examinations made to detect cases of defective color perception were so unsatisfactory in the railway and marine service that in 1890 the British Board of Trade asked the Royal Society, "What is the best test for color blindness?"

A committee was appointed, including some of the most distinguished members of the Society, and after two years' work they unanimously reported as follows:

"1. That the Board of Trade, or some other central authority, should schedule certain employments in the mercantile marine and on railways, the filling of which by persons whose vision is defective either for color or form, or who are ignorant of the names of colors, would involve danger to life and property.

"2. That the proper testing, both for color and form, of all candidates for such employments should be compulsory.

"3. That the testing should be entrusted to examiners certificated by the central authority.

"4. That the test for color vision should be that of Holmgren, the sets of wools being approved by the central authority before use, especially as to the correctness of the three test colors, and also of the confusion colors.

* Lovibond's tintometer, Rood's flicker photometer, or Abney's color-patch apparatus might be of value in this direction.

If the test be satisfactorily passed, it should be followed by the candidate being required to name without hesitation the colors which are employed as signals or lights, and also white light.

"5. That the tests for form should be those of Snellen, and that they should be carried out as laid down in Appendix 6. It would probably in most cases suffice if half normal vision in each eye were required.

"6. That a candidate rejected for any of the specified employments should have a right of appeal to an expert approved by the central authority, whose decision should be final.

"7. That a candidate who is rejected for naming colors wrongly, but who has been proved to possess normal color vision, should be allowed to be re-examined after a proper interval of time.

"8. That a certificate of the candidate's color vision and form vision according to the appointed tests, and his capacity for naming the signal colors, should be given by the examiner; and that a schedule of persons examined, showing the results, together with the nature of the employments for which the examinations were held, should be sent annually to the central authority.

"9. That every third year, or oftener, persons filling the scheduled employments should be examined for form vision.

"10. That the tests in use, and the mode of conducting examinations at the different testing stations, should be inspected periodically by a scientific expert, appointed for that purpose by the central authority.

"11. That the colors used for lights on board ship, and for lamp signals on railways, should, so far as possible, be uniform, and that glasses of the same color as the green and red sealed pattern glasses of the Royal Navy, should be generally adopted.

"12. That in case of judicial inquiries as to collisions or accidents, witnesses giving evidence as to the nature or position of colored signals or lights should be themselves tested for color and form vision."

In a further discussion of the subject the committee make a number of statements which it is well to keep in mind. "The variations in the amount of this deficiency in color perception are numerous, and when small are often exceedingly difficult to classify. We have to regard these deviations from normal vision more from a practical than from a theoretical standpoint, and in testing for them we have to take the broad view that the color blindness which has to be detected is that which may be dangerous to the public in the industries already mentioned." "In a testing room, when signal lights are used as tests, color-blind persons may possibly be able, with practice, to name the different colored signals correctly, recognizing them by their relative brightness, and by their dilution with neutral color. The practical tests the committee have carried out confirm this view; men who are absolutely color-blind having passed such a test without being detected. It might be supposed that if the colors of signals could be rightly recognized in the testing room they would be equally well recognized elsewhere. It must, however, be recollected that the atmospheric conditions of the testing room are often very different from those which are found outside. As a rule any judgment of the color of a signal which depended on its brightness would be fallacious. A dirty glass or a misty atmosphere would introduce a liability to error. The red signal of danger might then be mistaken for the green or white signal of safety, and vice versa. It must also be remembered that a signal light, as a rule, has no white light adjacent to it with which to compare it, and thus a decision as to whether a light is neutral or slightly colored has to be arrived at under great disadvantages." "In the color blindness induced by disease or injury, although the loss of color sense is usually confined to a small area of the retina, yet as it is the central area and therefore the part on which the image of small objects naturally falls, the danger of mistaking a color is as great, and even more so than in congenital color blindness."

"The standard test colors which have been approved by Professor Holmgren have been referred to the spectrum. The first standard is a light green color, which can be matched with a green in the spectrum (λ 5660) when forty per cent. of white is added. The second standard skein is light purple or pink, and its complementary color is a green in the spectrum (λ 5100). The color is diluted with about forty per cent. of white." "All tests in which the wools are suspended from a bar, even though the test skeins may be of proper color and tone, should be avoided, since the order of arrangement might be ascertained by some means or another by those who are tested. It is quite true that the order might be changed; but in an examination of this character, where large numbers may be under trial, any frequent changing of the order would be impracticable, and hence there would be no security that the test was efficient. The same objection applies to all diagrams of color which the examined are required to match with standard colors." "The Committee would not insist upon the examiner being a medical practitioner, but it is probable that a medical training would be of advantage. They are further of opinion that there should be a periodic inspection of the different testing stations by duly qualified ophthalmic surgeons, who should report upon the condition of the testing appliances and upon the mode in which the tests are carried out: and who might be the authorities to whom an appeal from a rejected candidate should be referred. In no case should any test be allowed in substitution of those recommended, though supplementary tests might be tried if desired. The passing or rejection of the candidate should always be based on the tests which have been laid down." In 1892 a Committee of the British Medical Association made a report on "The Efficient Control of Railway Servants' Eyesight," in which they recommended: "2. That the test for color sense should be that of Holmgren carried out in strict accordance with his direction. After this test has been passed the candidate should be required to recognize and name promptly the colors used in signaling. We wish to emphasize the importance of employing glass of standard color in railway signal lamps: as recommended by the Committee of the Royal Society."

In Holland the rules governing the examination of the eyes of the employees of the Dutch state railways are more complete than in any other country. They were arranged by Prof. H. Snellen, who is also the consulting ophthalmic surgeon, to whom all cases of doubt are referred, but the ordinary examinations are made by ophthalmic surgeons at various convenient places on the lines. Article 10 provides that "The color sense is to be estimated—(a) qualitatively, by pseudo-isochromatic tables of Stilling, and with wools, according to Holmgren's method; (b) quantitatively, by Donders' method, which must be applied in every instance without exception."

In a small and compact country like Holland, it is possible to carry out methods of examination which would not be practicable in the United States, where one railroad company in several instances operates more than seven thousand miles of track, and has an army of employees widely scattered along its lines. My experience with two large railways in the United States, the Burlington and the New Haven systems, has shown that very good results can be obtained by having the examinations for color perception made in accordance with carefully prepared instructions, drawn up by an ophthalmic surgeon who has had some experience in these matters, the routine examinations being made, in one case by the medical examiners of the road, and in the other case by employees selected for this work on account of their good judgment and intelligence; in each case the examiners were first carefully tested to make sure that their color perception was normal, they were then instructed in the methods to be followed in making the examinations, and were provided with printed instructions and blanks on which the records of the examinations were to be made, and with the necessary materials for making the tests, these materials having been previously approved by the ophthalm-