COLOR BLINDNESS.

— W. M. Browne

Supplemental Report on Ophthalmology

READ BEFORE THE

MEDICAL SOCIETY OF THE STATE OF CALIFORNIA,

April, 1882,

—BY—

A. M. WILDER, M. D.,

Late Surgeon and Brevet Lieutenant Colonel U. S. Volunteers; Prof. Ophthalmology and Otology, Medical Department, University of Cal., etc.

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SUPPLEMENTAL REPORT ON OPHTHALMOLOGY.

By A. M. WILDER, M. D.

COLOR BLINDNESS, ETC.

Mr. President and Members of the Medical Society of the State of California: At the meeting of the Society last year, it was my privilege, as Chairman of the committee, to make a Report on the Status and Progress of Ophthalmology. Considerable space in that report was devoted to the consideration of color blindness and imperfect vision; the great importance of these defects, relative to the safety of the general traveling public; and the necessity of having some legislative action taken in this State, and on this coast, in view especially of the large amount of travel constantly going on both by land and by sea.

The action of the General Government at Washington upon this subject, was alluded to, and there were embraced in the report, as supplements, circular orders from the Treasury Department; orders from the Army and Navy Headquarters; the Connecticut State law, and the provisions for carrying out the same adopted by the State Board of Health; the Massachusetts State law, etc.

You will remember that a resolution was adopted referring the portion of the report devoted to color blindness, etc., to the Committee on Legislation. Inasmuch as there has been no session of the Legislature since our last annual meeting, and as there will be a session of the same during the coming winter, I have desired to call your attention again to this matter (of such serious importance to the welfare, comfort, and safety

of the community), and to ask that some more definite action be taken to bring the subject before our law-makers, indorsed by the weight of the State Medical Society, with a view of securing such action as would oblige railroad corporations, shipping and steamship lines, to have their employes subjected to uniform, systematic, and exact examinations as to defects in the color sense and visual power. Referring you to the report made last year, and published in the transactions, I beg further to call your attention to some of the work that has been done in this direction during the past year in other portions of the country and abroad. The literature of color blindness is at present quite limited, but as its importance becomes more generally appreciated by the profession and the community at large, this deficiency will be remedied. Dr. Henry W. Williams, of Boston, Professor of Ophthalmology in Harvard University, in his recent work on the eye, published in 1881, gives considerable prominence to the question of color blindness; and no text-book or work on the general diseases of the eye can in future ignore this important subject.

According to Jeffries, the first publication, in the English language, on color blindness, was a monograph from Professor Wilson, of Edinburgh, in 1852, which failed to draw that public attention to the subject which its importance demanded, principally for the reason that at that time there was no ready practical test known for determining the degree of the defect.

In 1876, or 1877, Professor Holmgren, of Upsala, Sweden, published a monograph on "Color Blindness, its Dangers and Detection," and gave us the simple, sure, and rapid method of determining the defect, by means of the Berlin wools or worsteds.

Dr. Jeffries, of Boston, recognizing at once the great value of this method, began his valuable labors in this direction, which he has so indefatigably continued ever since.

In 1880, Dr. Jeffries published his book on "Color Blindness, its Dangers and Detection," which he claims to have

been the second work published upon the subject in the English language.

Principally through the efforts of Dr. Jeffries, the United States Government very speedily took the matter in hand, and an abstract of Dr. Jeffries book as a manual, together with the Holmgren worsteds, were issued to the Medical Officers of the Army, Navy and Marine Hospital Service, and examinations as to color blindness were made obligatory, in addition to the regular physical examinations required for entering into and promotions in the Army and Navy Service of the United States. The promptness with which our General Government grasped this question, has not been duplicated in the matter of railroad transportation, and until each State enacts careful provisions for enforced examinations, we need not look for anything very satisfactory to be accomplished in this direction. The Pennsylvania Central Railroad Company has, however, taken the matter in hand, so far as its lines are concerned, and has had between twenty thousand and thirty thousand of its employes examined. I have been unable to obtain the results of such examinations.

The enormous increase of late years in steamboat lines, coasters, ferry boats, tugs, etc. (thus largely increasing the danger of collisions from the misunderstanding and misreading of signals), and the network of railroads throughout the country, with their innumerable number of trains in constant motion, rendering it of the highest importance that the persons intrusted with the running and management of the same shall be fully competent, both to the stockholders and the traveling public, call emphatically for legislative action in this matter of color blindness and defective vision.

We have alluded to what has already been done by the Departments of our General Government. Connecticut and Massachusetts are thus far the only States that have taken legislative action upon the subject. The Connecticut law was very exact and complete, and its provisions were thoroughly carried out by the State Board of Health, in the

execution of which the necessity of the law was abundantly demonstrated.

The Massachusetts law was so loosely drawn as to render it nearly worthless, and to cause the Governor of the State to refer to its defects in his inaugural. It has since been referred back to the railroad committee for revision. The Act, as passed, appeared in the report of last year. Accompanying this paper is the original draft of a law as proposed to the Railroad Committee, but for which the present law was substituted.

In European countries the importance of this question has been much more generally understood and acted upon.

In Sweden, since 1877, all railroad employes, and employes of the merchant marine, have been compelled by Government enactment to submit to expert examinations, and to come up to a certain fixed standard before being permitted to enter service.

Belgium has followed suit, as will be seen by a report made by Drs. Warlomont and Moeller, a committee appointed by the Belgium Minister of Public Works, an abstract of which report forms a part of this paper.

France, Prussia, Austria and Switzerland, have fallen into line.

In November, 1880, the Council of the British Ophthalmic Society appointed a committee "to consider defects of sight in relation to the public safety, with authority to communicate thereupon with the Government on the part of the Society, if they should think fit." I present herewith an abstract of the first report of the committee, made through its Chairman, Mr. Brailey. The committee closed their report by saying: "The relation of the subject matter of this report to the question of the preservation of life in traveling, cannot fail to impress itself upon every one, but it has been thought expedient that our statement of the subject should end here, leaving to a future time the discussion of its practical bearings in relation to the use of colored lights in signaling, both by sea and land."

At the meeting of the Ophthalmological Section of the recent International Medical Congress, Mr. Bowman, the President, referred to this question in his opening remarks. The Section adopted unanimously a series of resolutions as to "tests of sight suitable to be enforced in the case of signalers and lookout men; and national arrangements for a uniform system of maritime, coast, and harbor signaling, with a view to the safety of life and property."

The remarks of Mr. Bowman, and the resolutions, are made a part of this paper. The committee which drafted these resolutions represented twelve different countries, and they recognized the action which had already been taken by our own Government, looking to the formation of an International Commission for the settlement of these questions, by embodying in the resolutions the following: "It is understood that this question of International Commission is about to be submitted to the Legislature of the United States of America, supported by a petition largely signed by scientific men of that country,"

At the Centennial Meeting of the Massachusetts State Medical Society, held June 8, 1881, the following preamble and vote were unanimously adopted:

"*Whereas*, a petition has been presented to Congress, asking for the calling of an International Commission, to consider and agree upon standard methods of testing visual acuteness and color blindness, and standard requirements of these necessary qualifications in the navies and merchant marines;

"*Voted*, that the Massachusetts Medical Society heartily approves of the proposed International Commission, and hereby directs the Secretary of the Society to transmit this vote to Congress when next assembled."

The following Joint Resolution is at present before Congress:

"*Resolved*, by the Senate and House of Representatives of the United States of America, in Congress assembled, that the President is hereby authorized and directed to appoint, by and

with the advice and consent of the Senate, some suitable person, qualified for such service, who, with one line officer of the navy, and one medical officer of the navy, to be detailed or designated by the Secretary of the Navy, shall attend and represent the United States in any International Congress or Convention held by the authority of law in any European nation, to consider and act upon said subject; and the sum of ten thousand dollars is hereby appropriated, out of any money in the treasury not otherwise appropriated, to be used and expended, or so much thereof as may be needed, under the direction of the President, to compensate the person so appointed, and defray the necessary expenses of the person so appointed, and of the officers of the navy so detailed or designated. And the person so appointed, and the officers of the navy so detailed or designated under the provisions of this Act, shall join in the report of the proceedings of such Congress or Convention, and of the conclusions reached thereby, if any, to the President, to be by him laid before Congress, to the end that an international system of examinations for color blindness, and tests for visual acuteness, and standards for colors for signals used at sea, may be established by law."

I have prepared the following resolutions, which I have requested the Secretary to present to the Society, and I ask for them your favorable consideration:

Whereas, the members of the California State Medical Society fully recognize the importance of having definite and uniform standards of examination for color blindness, and tests for visual acuteness, in persons employed in the navy and merchant marine; and

Whereas, there is now pending before Congress, House Resolution No. 135, being a Joint Resolution relating to color blindness and visual acuteness in persons employed in the navy and merchant marine, and providing for the holding of an International Commission for the purpose of determining definite standards for the government of all nations; therefore, be it

Resolved, that the members of the California State Medical Society, assembled in annual meeting, do heartily approve of the provisions of said House Resolution No. 135, and do urge upon the California Delegation in the Congress of the United States, to do all in their power towards securing the passage of said Resolution; and be it further

Resolved, that the Secretary of this Society is hereby instructed to forward, at once, to each Representative and each Senator from California, now serving in the Congress of the United States, a copy of these Resolutions.

So little attention has hitherto been given the subject of color blindness that it is not easy to point out instances in which accidents have certainly resulted from this defect, but a striking case has recently been brought to light. *Vide Quarterly Journal*, for 1881, "A collision occurred several years ago between the tugboat Lumberman and the steamer Isaac Bell, near Norfolk, in which ten lives were lost. The Coroner's inquest developed no definite results, but it was supposed that one of the pilots was drunk. The pilot of the Lumberman was recently examined by a Marine Hospital Surgeon and found to be color blind, and it is reported that the other pilot has the same defect. In the investigation of the famous Norwalk drawbridge accident, it was shown that the red signal was properly displayed but was disregarded."

In my report of last year appeared the following:

"The dangerous defect in so large a number of persons cannot but explain the cause of many marine disasters otherwise unexplainable."

A classification in Europe of the reports of 2,408 accidents, between 1859 and 1866, showed:

"Want of skill, carelessness of the ship personnel, or accidents which it was impossible to prevent or avoid	1,562
"Error of pilot or captain	215
"Want of observation, or proper interpretation of the rules of the road	537
"Undetermined causes	94
"Total	2,480

"Under the last three heads are eight hundred and forty-six accidents which might have been due to color blindness or defective vision."

As it has been shown by very extensive examinations that about four per cent of all males in the civilized world are color blind, it is fair to suppose that the same proportion will be found in the service of railroads, navies, and merchant marines. Experience has proven this to be true. From the same process of reasoning we may easily infer that four per cent of accidents may be traced to defective color sense; but allowing that only one per cent of accidents arise from this cause, the responsibility is not lessened, and the necessity for protection remains the same.

I have devoted some space to the question of "expert testing," for the reason that there is a disposition on the part of the laity, and I am sorry to say, on the part of some members of the profession, to make light of the whole subject.

In face of the authorities I present to your consideration the action of the various civilized nations quoted, and the action of our National Government, it seems to me that this Society cannot fail to appreciate the importance of having not only international and national provisions for protecting our navies and merchant marines, but also the vital necessity of having legislative action in this State for the protection of persons traveling by rail, on our internal waters, and coast lines. I would most earnestly urge upon the Society to take special action at this session, with a view of bringing the subject before the Legislature in proper shape for the securing of suitable enactments.

APPENDIX I.

Context of a Bill suggested to the Railroad Committee of the Massachusetts Legislature, in place of which was enacted the Law which appears in my report of last year.

"Section 1. Every railroad corporation within this Commonwealth, shall, at its own expense, on or before the first day of November next (1881), cause every person within its employ as locomotive engineer, or fireman, train conductor or brakeman, station agent, switchman, gatetender, or in charge of signals, to be medically examined with regard to his visual power and color blindness, and shall, after said first day of November next, cause every additional person employed by it in any of such capacities to be so examined before entering upon his duties, and shall thereafter cause all such persons to be, from time to time, re-examined with respect to visual power and color blindness. All such examinations and re-examinations shall be conducted in the manner hereinafter provided for.

"Sec. 2. There shall be appointed by the Governor and Council, on or before the first day of June next, a sufficient number of medical experts to make the examinations of railroad employes as designated in Section 1 of this Act; said experts may be removed at any time, and their number increased or diminished at the pleasure of the Governor and Council; said experts shall, subject to the revision and approval of the Governor and Council, frame rules in relation to the examination and re-examination of said railroad employes in reference to visual power and color blindness, and the form of certificate to be issued to the examined, and may change said rules from time to time, subject to the said revision and approval; said

Governor and Council shall cause certified copies of said rules, on or before the first day of July next, to be published, at least once a week for three successive weeks in some daily newspaper in the city of Boston, and to be mailed to the post office address of every corporation operating a railroad in this commonwealth, and shall likewise notify said corporations, by advertisement and mail, of any changes in said rules, the expenses of which shall be paid from the treasury of the commonwealth. The Governor and Council shall decide on, and may, from time to time, change the fees said experts shall receive from the railroad corporations for services and expenses. Said experts shall report annually, on or before the first day of February, to the Legislature, the results of their examinations up to January first of that year.

"SEC. 3. Any railroad corporation operating a railroad in this commonwealth, employing, after the first day of November next, in any of the capacities specified in the first section of this Act, any person who does not possess a certificate of fitness duly issued in accordance with the provisions of this Act, shall, for each and every offense, be punished by a fine of not less than two hundred dollars or more than one thousand dollars."

APPENDIX II.

ABSTRACT OF DR. BRAILEY'S REPORT.

The report of the committee appointed to inquire into defects in sight in relation to the public safety, was read by the Chairman, Dr. Brailey, before the British Ophthalmological Society, at a special meeting held on the seventh of April, 1881. The inquiry extended over five months, and the examinations were conducted by gentlemen of experience. The material was collected from various sources, consisting of public institutions, schools (public and private), the metropolitan police, and the Coldstream Guards. The number examined was 18,088, of which 16,431 were males and 1,657 were females. Deducting from the males certain groups of cases, specially selected, in the expectation of finding peculiarities, there remained 14,846, with an average of color defects of 4.76; whilst among females, making similar deductions, there remained 489, with a percentage of only 4 per cent. Among male Jews it was 4.9; among male Friends, 5.9 per cent; among the male deaf and dumb it reached the high rate of 13.7 per cent; among the females of each group the percentage was less high.

All persons with pronounced blindness to red and green were found utterly incapable of naming with certainty a red or green light when exhibited singly. All failed also when the distance and intensity of illumination of the colored light were unknown. Red blindness appeared a little more common than green blindness. With regard to the causation of color blindness, Dr. Brailey regards it as due in most cases to a congenital physical defect, either in the eye or brain, occurring in the first instance as an accidental variation, and when

once existing, liable to be transmitted by descent. It was to the frequency of intermarriage that the high percentage among the Jews and Friends was to be ascribed. The heredity of the defect was strikingly illustrated by some cases alluded to by Drs. Frost and McHardy. The former referred to a color-blind who had seven sons, six of whom were known to be color blind. None of the daughters had the defect, but one had a color blind son. Dr. Brailey believes that color blindness, especially the slighter forms, may arise from the defect of color education in infancy, and hence it is that females, from the greater attraction colors have for them at an early age, and the greater attention paid, as a sex, to color distinctions, are less frequently the subjects of the defect.

The President alluded to the urgent need of imperial and international legislation in reference to color blindness and visual acuteness; also, to the great and disinterested service ophthalmologists, by lending themselves to these investigations, were rendering to the traveling community, whose safety could not be secured until the color blind had been eliminated, as could only be done by expert examiners, from those who were called upon to distinguish between colored signals.

APPENDIX III.

Remarks of Mr. Bowman, President of the Ophthalmological Section of the International Medical Congress of 1881, *with copy of Resolutions adopted.*

Mr. Bowman, President of the Ophthalmological Section of the International Medical Congress, held last August in London, in the course of his address used the following language:

"The precision of our modern methods of determining the accuracy of sight, and of the sense of color, has at length made it possible to urge with increasing earnestness, on authorities responsible for the lives of travelers, whether by land or sea, the necessity of enforcing adequate test examinations, not only candidates before engagement, but subsequently, at stated intervals, on all persons employed where good sight is an essential qualification. If this be important in regard to railway drivers, guards and signal men, it is even far more so in the maritime service. On land each Government is, in a very direct manner, held responsible to its own citizens, and accordingly much has been done of late years in several countries, though effectively I fear in very few, to institute strict periodical examinations under state authorization and control. As to these, perhaps a very close uniformity through different countries is not so very necessary, however desirable. But it is matter of common and urgent concern to all nations, that, on the open seas, on coasts and in harbors, a uniform system should prevail as to the due and sufficient and periodical testing of the sight of those who may be in the position either to give or to observe signals, on the prompt discrimination of which a multitude of precious lives may at any moment depend.

"And I trust it may not be very long ere such a uniform system of tests as science can now supply, and also the obligation to put these in force among their own subjects, will be willingly accepted by all civilized States."

Resolutions adopted by the International Medical Congress, London, 1881, as to "Tests of Sight suitable to be enforced in the case of Signallers and Look-out Men, and other persons by Land or Sea, with suggestions as to International arrangements for a uniform system of Maritime, Coast and Harbor Signalling, with a view to the safety of life and property;" followed by explanatory remarks under the several articles.

A—WITH RESPECT TO LAND.

(1) That the recommendations of the last International Medical Congress, held at Amsterdam in 1879, are accepted by the present Congress as forming the most suitable basis upon which every government may frame its own regulations as to its railway service. They are contained chiefly in Article XII of the "Projet d'un reglement pour l'examen des facultes visuelles du personnel des chemins de fer," laid before and accepted by the Ophthalmological Section of the Amsterdam Congress, which is nearly as follows:

"For admission as *driver* or *stoker* is required a healthy condition as regards habitual congestion or irritation of the eyes and eyelids; *for each eye*, complete field of vision; normal acuity and refraction; color sense at least four-fifths of the normal; total absence of commencing cataract, or any other progressive disease.

"For admission to other *railway service* is required a healthy condition as regards habitual congestion or irritation of the eyes and eyelids; *for each eye*, complete field of vision, total absence of cataract or any other progressive disease; *for one of the eyes*, normal acuity and refraction; color sense at

least three-fifths of the normal; *for the other eye*, sight of at least half the normal as regards both acuity and color sense."

B.—With respect to Sea.

(2) That in *ocean-going ships* and in *all steamers*, especially those carrying passengers, there should always be in actual control of the helm a person possessing *with the two eyes together, without glasses*, normal sight, both as to acuity and colors, and that, *in addition*, in such ships, *at least one* of the persons actually on the lookout should be similarly qualified.

(3) That, in vessels engaged in the coasting trade, every person liable to take charge of the helm should possess *with the two eyes together, without glasses*, sight equal to at least two-thirds of the normal, both as to acuity and colors.

(4) That all persons engaged in the marine signalling, ashore or afloat, and all pilots, should have normal sight, both as to acuity and colors, as defined in Article 2.

(5) That hypermetropic persons, although satisfying the requirements of Articles 2, 3 and 4, should, nevertheless, not be admitted, if before the age of eighteen they have a manifest hypermetropia of one dioptra.

(6) That re-examinations should be made at the age of forty-five.

(7) That the examinations should be conducted by persons of recognized competency, under the direction of a central medical authority in each country.

(8) That an international commission should be constituted, to fix upon such further measures as to signals as may be necessary for safe navigation, and especially, upon the standard colors, and the sizes of the signals employed.

EXPLANATORY REMARKS.

(The Numbers Refer to the Resolutions.)

A.—As to Land.

(1) The signal services on land, though quite as important, are not so purely an international matter as those having reference to the sea. Many countries have already established legislation in this respect, and others are introducing it by degrees. It is believed that the standards now recommended may be of general utility, especially in the case of conterminous countries. The mode of examination, for colors especially, is here, as at sea, of the highest possible importance.

B.—As to Sea.

It is obvious that regulations having an international character become every year more urgently required, from the increasing number, size, and speed of vessels.

In view of the practical difficulties with which all compulsory examinations are attended, it has been sought—

(*a*) To limit the examination in each case to what is strictly necessary.

(*b*) To require them only when absolutely indispensable, and of the smallest possible number of persons.

(*c*) To simplify the methods as much as possible.

On large ships, many sailors not required for the helm, or to be responsible for the lookout, may be admitted without certificate of examination; but as it will be in the interest of all to be possessed of such a certificate, which would represent a higher competency, it may be expected that many would themselves seek for it from whom it would not necessarily be demanded; and facilities for obtaining it should at all times be at hand in maritime ports.

(2) Good sight *without the aid of* glasses is required, because glasses fail to help just where clear sight is most needed, *e. g.*, in storm, rain, or fog.

Acuity of Sight.—Complete acuity is not more than sufficient, and even scarcely sufficient, having regard to the increasing number, size, and speed of steamers. But it will be practically enough if at sea this complete acuity is attained by the use of *both eyes combined.* The number of persons excluded under this rule will be much less than if complete acuity for *each eye separately* is exacted.

The acuity is supposed to be determined by viewing letters or signs at a certain distance, under a certain angle, on the principle of the test-types of Snellen.

Color Sense is supposed to be tested by pseudo-isochromatic tables, on the principle of those of Stilling, subject to control by the use of light transmitted through colored glass, in imitation of signal lights. This control will also aid in detecting central scotoma for colors, in the very rare cases where it might co-exist with the required acuity.

Holmgren's excellent tests have been already extensively adopted. But their use demands more skill in the examiner. Tests well selected on the principle of Stilling might be very well adopted as standards for ascertaining normal color sense, as well as definite degrees of color sense below the normal. The principle of Stilling has been recommended as affording a quantitative as well as a rapid qualitative test.

(3) A lower standard is fixed in the coasting trade (excluding steamers), because the vessels are smaller and the speed less. Moreover, a demand for full acuity would render it difficult to procure a sufficient number of sailors, as each hand must be liable in small vessels to serve at the helm.

(4) It is obvious that the persons here named must have full acuity and color sense.

(5) Persons having a manifest hypermetropia above that here indicated, would not possess, at the age of thirty-five or

forty, without glasses, the needful degree of acuity; it is better, then, both for themselves and the service, that they should not be admitted at all.

(6) The attendant practical difficulties have caused one re-examination only to be advised at the age of forty-five. It has been found that the very great majority of persons once admitted as having good sight, have retained it up to that age. A great number, no doubt, have been admitted hitherto without sufficient examination; still, it would not be practicable to institute a general examination of those already in the service. Nevertheless, it would be desirable to examine anew, in the case of passenger steamers, all those responsible as helmsmen and lookout men.

The Congress recommends that surgeons of ships should be qualified to exercise special surveillance as to the sight of those employed in these capacities on board.

(7) A central medical authority is requisite to insure the perfection of the system and its uniformity. He should propose the examiners, and be responsible for their fitness. They should be men of ascertained competency, and as far as practicable, qualified as medical specialists.

(8) The measures recommended in Articles II to VII should be brought into operation without delay. But an international commission would still have to determine the precise color of the glass, securing uniformity in that as well as in the size and disposition of the signal lights.

The Congress lay the greatest stress upon the appointment of this commission in respect of marine signaling, as quite indispensable for the attainment of the object in view. The commission would have to inquire into, and decide upon, many matters on which information is at present incomplete, and regarding which only a few points have been touched upon in Article VIII.

Every government, especially the maritime governments, should be requested to place one or more members on the

commission, and chiefly experienced naval officers and medical specialists.

It is understood that this question of an international commission is about to be submitted to the Legislature of the United States of America, supported by a petition largely signed by scientific men of that country.

The resolutions emanated from the Ophthalmological Section of the Congress, and were drawn up, in the first place, by a committee representing twelve different countries.

APPENDIX IV.

How the Color Blind see Colors, or the Physiology of Color Blindness.

But little has been done so far in the investigation of how the color blind see colors. Obviously it is very difficult to determine this matter, inasmuch as it is impossible for a normal-eyed person to make himself see as a color-blind.

Professor Holmgren, of Upsula, Sweden, has recently made great advance in this direction. The first results of his investigations were published in 1880, a translation of which, made by Dr. B. Joy Jeffries, appeared in the *Boston Medical and Surgical Journal* of June 2d, 1881.

Starting out with the proposition that to obtain a definitely correct answer to the problem of "how the color blind see," it is necessary, not only to preserve one's normal vision, but also to see with the eyes of the color blind. He says:

"The normal-eyed must therefore become a part of the color blind, and exist in his sense, whilst still preserving his own."

With the knowledge that color blindness is hereditary, and transmitted in accordance with certain laws, and that the defect is not constant, but affects certain of the offspring while sparing others, and also that the defect is transmitted unequally, so that one eye might be normal, or nearly so, while the other might be nearly or totally color blind; and further, that color blindness may be acquired, and affect the eyes differently, Professor Holmgren conceived the idea of finding some person or persons thus constituted, and by careful examinations ascertain by means of the normal eye of the individual how the color blind eye of the same individual saw colors. He was so fortunate as to have opportunity of examining two

such cases—one having monocular violet blindness, and the other monocular red blindness. The principle governing all the details of the examinations was that of comparison. He says:

"I let the normal eye compare the sensations of the color-blind one with its own, and put the result thus obtained in a form readily to be appreciated by all normal-eyed."

The full details of his examinations are promised in a future publication. "It has been assumed on good ground that the color blind see only two principal colors in the spectrum." These are the two fundamental colors of his subjective color system.

"In the violet blind the fundamental colors are red and green. The two base colors of the red blind are yellow and blue," and these results he states "to be in complete harmony with the Young-Helmholtz theory."

APPENDIX V.

Statistics of Color Blindness in Denmark.

Dr. O. E. DeFontenoy, in reporting on the progress which has been made in Denmark, as to the relations existing between color blindness and the practical pursuits of life, states that the authorities have carefully examined all the persons engaged on the railroads, and all candidates for employment on the lines are required to show that they have a normal color sense. In 9,659 cases examined, from eight years of age upward, including persons of all grades of society, 217 were found to be color blind; 1,001 of those examined belonged to the superior classes, and showed thirty-one defective, or a little over three per cent, while out of 3,491 of the lower classes there were 134, or nearly four per cent. Out of 2,714 children, from eight to sixteen, there were forty-one color blind, of whom thirty-six were boys and five girls.

All the examinations made showed a marked difference between male and female.

APPENDIX VI.

Abstract of Report to the Belgian Minister of Public Works.

Drs. Warlomont and Mœller, the committee appointed by the Minister of Public Works in Belgium, to report upon the vision of railway employes, with special reference to color blindness and acuity of vision, recommended, in their report, that in future all persons employed on the State railways should be placed, after examination, in one of the following classes, viz: *Very Satisfactory; Satisfactory;* and *Unsatisfactory*—the latter being excluded from entering the public service. The requirements of the first class to be: first, eyes and eyelids healthy, and free from all habitual irritation or congestion; second, normal acuity ($\frac{20}{20}$), refraction perfect within the dioptric; third, a normal field of vision; fourth, the power of distinguishing colors to the extent of $\frac{1}{5}$ at least; fifth, complete freedom from cataract or other disease.

For the second class, the conditions are the same, except that in one of the eyes visual acuity must be normal; in the other it may be $\frac{1}{3}$, and the perception of color must be at least $\frac{2}{5}$ in one and $\frac{2}{3}$ in the other.

Holmgren's color tests are recommended; errors of refraction to be tested in the usual way.

APPENDIX VII.

Expert Testing.

The *Boston Medical and Surgical Journal*, of March 10th, 1881, contained an editorial on the bill reported by the Railroad Committee of the Massachusetts Legislature, in reference to the examination of employes for defective sight and color blindness, complaining very strongly against the loose manner in which the bill was drawn. The *Boston Daily Advertiser* noted the editorial and, after quoting it, added: "The *Journal* is quite right, and it will probably find the strongest support among those railroad men who have been examined by specialists." Moreover, the experience of Connecticut, and several European States, shows that an examination for color blindness is not worth much unless it has been conducted by a specialist. In the bill, the words "some competent person" should read "a responsible ophthalmic surgeon." The bill was passed as reported by the committee, and subsequent experience has shown conclusively that the criticisms were correct. The Governor of the State called attention to the matter in his inaugural as follows: "Both in justice to the railroad employes and for the safety of the traveling public, it should be provided that the examination for color blindness and other defective sight, required by the Act of last year, be made by persons whose competency is beyond question. The statute is too loose in this particular."

The Governor and Council, as President and Directors of the Troy and Greenfield Railroad and Hoosac Tunnel, had full opportunity of witnessing the workings of the law (which has since been referred to the Railroad Committee for reconsideration). The *Journal* for February 2d, 1882, has another editorial on the question of expert examination. It refers to the

Act proposed to the Railroad Committee last year (in place of the one finally reported and passed), which appears in another part of this paper, and also to the one proposed for an Inter-State Commission, to agree upon what was fairly required of employes engaged in moving trains in respect to their power of sight and color sense, and standard methods of testing these by those competent to do so. It then goes on to speak of the report of the committee appointed by the Council of the British Ophthalmological Society, in November, 1881, "to consider defects of sight in relation to the public safety, with authority to communicate thereupon with the government, on the part of the Society, if they should think fit."

An abstract of this report accompanies this paper, but in this connection I use the *Journal's* quotation of the portion in relation to expert testing:

"Your committee becomes more and more convinced that a competent examiner is not made in a day, or even in a month, and that, even with large experience, much judgment and capacity are needful to interpret aright the acts of the examined. This necessity is perhaps most strongly exhibited in the case of intelligent persons who are completely color blind. Such persons, though they may have a much feebler appreciation of the difference between red and green, for example, than is normal, may, after accurate observation and comparison, separate the red skeins of wool from the green; when tested, however, at various distances with colored lights, their defects are startlingly apparent, and it becomes clear that they are totally unfitted for responsible posts in which rapid appreciation of color at a distance is required."

Professor Donders, the renowned author of the classical work on "Errors of Refraction and Accommodation," writes from Utrecht, December 15th, 1879, as follows:

"I must willingly testify that it is my full conviction that only medical experts, ophthalmic surgeons, should be employed in testing color perceptions and acuteness of vision."

From a letter written to Dr. Jeffries, by Professor Holmgren, under date of December 26th, 1879, I quote as follows:

"I must most decidedly insist that the testing for color blindness of railroad employes can be safely conducted only by competent persons. In my publication of 1877, I have stated this most definitely, and found no cause since then to change my opinion; on the contrary, my subsequent experience has forced me to hold still more closely to this belief. I remarked in my book, that at first, here in Sweden, the tests were left to the railroad officials. This, however, soon proved insufficient and useless; for example, one official found amongst his employes ten per cent color blind. Another official, on the contrary, found little or no color blindness. Subsequent examination proved both officials to be equally incorrect.

"Medical education is here *absolutely* necessary. My method is practically so simple that it would seem as if it would be successful in the hands of any physician. In my experience, however, this has never been the case. Time has ever shown that quite competent ophthalmic surgeons have misunderstood it, and applied it improperly. In Sweden the railroad surgeons have been practically and specially instructed *de visu*, by me, and we have had reason to be satisfied with this. There are many cases which *no* railroad official can detect or decide, and not even the ordinary railroad surgeon can be sure of. I therefore hold, what I have emphasized in my book, that the authorities must employ a man having the highest special knowledge, who shall be at the head of the control, and to whom all difficult and uncertain cases shall be referred; who thus shall have the final decision as to the employment or not of the particular person; and who shall instruct the railroad surgeons in reference to the detection and control of color blindness. To him all difficult questions are to be referred. He must be the highest appeal in all concerning this matter.

"It has been most fully shown that color blindness is no simple thing in its various relations to the railroads and the

marine. The laity must not therefore feel aggrieved that they have to rely so much on the authority of experts. A thorough knowledge of the *whole subject* is a necessary requisite for the testing of the employes. On the ground of what I have so far said, I must deny the competency of any railroad official to test the color perception of the others. Aside from all consequences, such practices are dangerous in two ways. First, the true color blind may be overlooked, and this will be practically all the more dangerous since the testing has thus decided their competency, and especially as these undetected color blind are thus *officially* assured that they can see correctly. Second, normal eyes may be thus declared color blind, and hence dismissed from service, which would be unfair in the highest degree. It is but right that every employe should be retained in his position who is thoroughly competent; and this can only be determined by an expert. I must express this more precisely. Only one expressly instructed in color blindness, can decide whether the color sense of an official is sufficiently normal to enable him, under each and every circumstance, correctly to distinguish the colored railroad signals. I here readily grant that not every normal eyed person possesses the other qualities necessary for railroad service; these are the requisites of the railroad official. There must, as I have repeatedly emphasized, be a strict line drawn between the competence of the physician and that of the railroad employe; each has his province and the border line must not be overstepped on either hand. The time has long been passed for knowing everything; division of labor is a law of our times, proving its advance. Railroad traffic is of course, here and there, a private system. In a certain sense, however, every railroad belongs to all mankind, and must therefore conform to the general public sentiment. The time is not, however, far off when we shall refuse to trust our lives and property to those roads where rules of safety are not thoroughly carried out.

"Here, in Sweden, the practice of medicine is not free—only those legally authorized can practice.

"We do not trust to the simple assurance of the butcher that his pork is free from trichinæ, and eat it, but require its being examined and stamped, officially, by a special expert, etc.

"In a word, in European eyes, railroad traffic does not afford the necessary safety, unless the color sense of the employes has been tested by competent surgeons, and with trustworthy methods. As to the methods, I need not remind that mine, with the worsteds, has proved preferable to all others. In support of this, we have only to compare results obtained by it, and those which the examinations on the German and Austrian roads gave."

The distinguished author, Dr. Hugo Magnus, with reference to examinations, uses the following language:

"We must express ourselves most decidedly and most earnestly, that under all circumstances this should be done only by those capable and experienced; and such are, in the largest majority of cases, ophthalmic surgeons. We do not hesitate to say that on the proper choice of those who are to carry out the test, its whole success depends. If the authorities make a mistake in this choice, the value of all the examinations is but questionable. Moreover, the security which the community feels for these tests is undermined. If the examination of the railway personnel is to be of value, the railroad authorities must look to it most carefully that this is placed in the hands of such persons only as from their special knowledge are fitted to undertake it. The examination by medical experts alone guarantees the requisite precision, and the consideration of all the possibilities accompanying such examination."