

EVIDENCE TAKEN BY THE COMMITTEE.

Evidence of Mr. HANBURY, of the Metropolitan Railway.

In the engine department, the men are examined as to perception of colour before they can qualify for drivers, but I think not for porters. If there is any doubt, we examine those engaged in traffic matters again, but not unless. We examine with the wool test, which I have here. We place this (a horizontal bar, from which were suspended skeins of wool about fifteen inches in length, and all bright colours) on the table in front of the man to be examined, and also a few skeins of wool, as an independent test. We ask the man what he understands by a danger signal; he says "red," naturally; then I ask him what colour represents a caution signal; he says "green." I say, can you find the colour representing the danger signal. He looks, and perhaps picks out red; if he hesitates at all in his first choice, we ask him if he is quite sure it represents the danger signal. He perhaps says it does. Then we ask as to the caution signal; also test him with regard to the skeins of wool, and request him to pair or match the colour with a similar one on the frame; and if there is any doubt, we ask him as to brown or blue. Suppose he were to take this (mauve), we should test him again. I have not found many such cases on the Metropolitan Railway. Men sometimes mis-name the colours. We do not ask him the names of colours, but ask him to match them. We also ask him to pick out the "danger" or "caution" signal colour, and we sometimes ask for the best red. We allow the man examined to make a minute examination between the colours. I cannot tell exactly how many men we have personally examined in this way, but I started my examinations in 1869, and have perhaps met with three cases of colour-blindness. I cannot give an estimate as to the number examined. The wool test is the first test which my Chief undertakes, but when going on the footplate (on the engine) I examine them again myself. Agricultural labourers as a rule answer the questions as to the colour of the signals correctly. I never heard of the engine drivers rejecting the firemen, nor the case of a man going colour-blind subsequently.

Question.—Do you have a certain proportion of men over-running the danger signal in a way which cannot be accounted for?—I know of the case of a man at King's Cross passing the danger signal—an aged man—but I found his colour-sight good. The positions of the coloured wools on the bar are not shifted. The firemen are only tested once or twice as to colour, and afterwards if promoted to be drivers. We do not test with lamps, nor as to alteration of colour by fogs. We test them with regard to other colours than red and green if there is an

evidence of the necessity. We explain that the red signal is a danger signal, but we very seldom find a man ignorant of this, they generally know something of the work. There is no test with lamps, because the glass which gives the green light is blue by day-light. It is not a signal green glass, it is a blue glass [the glass is peacock blue]. We test by day-light. If we have green glass with the lamp we find it an indifferent light. The glass we use with gas is of a very definite green.

In case of hesitation, would you ask the man for some further examination, such as to pick out wool which was not far from a given colour?—We should not pass them if there was any doubt. If a man chose the wrong colour I should not think of passing him. It rests with the examiner and not with a doctor to pass a man. Cases have occurred where men have not been able to pass the examiner's sight test and have been sent to the doctor, who has given a certificate. We have a sight test; the test is with the single eye—one being covered; also with both eyes uncovered. We do not test our men at night as well as by day-light, further than already explained.

If accidents only happen at night, should they not be tested in that respect?—No, I think not. We take it for granted if a man can tell red in day he can at night.

The CHAIRMAN: Suppose that there were wools here, none of which matched that (red) exactly, but some nearly; if you were to ask a man to pick out a near match, and he showed hesitation, would you regard him as suspicious?—If he picked out the nearest, I should consider he had answered correctly. The picking out of an exact match does not prove that a man is not colour-blind. I have seen a man pick out brown, and call it red. Red represents the danger signal, green represents caution. On the Metropolitan Railway our signals are so arranged that in the event of any breakage of the glass the white light is treated as a danger signal. [Mr. Rix was here called, and the witness applied the different tests to him, the questions being answered to the satisfaction of Mr. Hanbury, who remarked that Mr. Rix had good sight. He was, however, informed that that gentleman was colour-blind. Mr. Hanbury stated that they would pass him on the Metropolitan Railway. Mr. Rix was recalled, and his colour-blindness proved by Dr. Grossmann's test.]

The CHAIRMAN: Do you ever use Holmgren's test?—I have never seen it.

Mr. BRUDENELL CARTER: If Mr. Rix were confronted with a single light he would not be able to tell which was green. His deliberation shows he cannot do it in a moment?—I must admit that Mr. Rix being colour-blind is an eye-opener. We have about 500 men engaged in machine work, or on the engines.

Mr. BRUDENELL CARTER: Could you let me test them at some time by arrangement; it would not take long?—Yes, I should be very pleased to. I do not think painters painting various colours on the carriages and other things make mistakes

in colour. If they did, it would be discovered during their apprenticeship.

(By Dr. POLE): I do not know of any other railway using blue instead of green glass. I do know whether they use pure green. I have remarked that some glasses are bluer than others. We call them a better green. They are blue in daylight, but not by night.

(The Witness then withdrew.)

Evidence of Mr. WADDEN, of the London and South Western Railway.

The men entering the service of our Company are tested when they first enter, and again when they are promoted to be firemen, and every second year after that; and if during one of these biennial periods a man is promoted to driver, he is specially tested then. In the traffic department, every man is tested upon entering the service. They are tested in this way. I have brought the material in actual use for the purpose. These wools [the wools consisted of browns, drabs, sombre greens, one brighter green, and nondescript colours of very low tone] are placed upon a horizontal rod promiscuously, and the man asked to pick out three or four reds, blues, or greens, and if he makes an error in one of these, he is tested again with other colours. A man may have a good notion of colours, and not know what to call them. We do not find they mistake red for green. In addition to this test for the traffic department, in the locomotive department there is a night test. The room is darkened, and a box is fitted with a lamp at the back, and various coloured glasses are put in front, commencing with a small disc, perhaps the size of a pin's head, and gradually increasing till we get to one the size of a sixpence, the man being asked what colour he thinks is being shown to him. He is ten or twelve feet from the lantern. The smallest disc is the size of a pin's head, about one-eighth of an inch, or hardly as much, perhaps. We find the men are not so ready with the night test: they are more accustomed to colours by daylight, and find it easier in daylight to distinguish the colours than at night. These colours (wools) were provided by our storekeeper. I am not prepared to say under whose instruction.

Mr. BRUDENELL CARTER: Among these there is not a single red. I should say they were selected by a colour-blind person!

Capt. ABNEY: I am not colour-blind, but I should not know what to call some of these.

The WITNESS: Our locomotive foreman says many men fail in green who do not in red. I am told some men looked at that (green) and called it red. A further test is sometimes tried by sending men to the Ophthalmic Hospital, where there is a doubt, and I have been told that the hospital authorities confirmed our examination. This wool test is what we call the daylight test,

and the night test is with the absolute colours of signals. We give some puzzling colours at night, one of which is an orange light. The tints are graduated, we only use 4 glasses, white, red, green, and orange. All the glasses are of the same intensity. We do not try to imitate fogs, we simply have the lamp at the back of the glass, and the man in front; the room being darkened. I find larger lights are more easy to distinguish than smaller ones. The light behind the coloured glass is 10 or 12 candle power. It is not used with a bull's eye; it is a perfectly plain glass. Our signals are with bull's-eyes, with plain glass in front for colours. The plain glass is certainly a more severe test than with a bull's-eye, for I myself can see the flame through the colours.

Question.—If you look at the blue glasses in a lamp outside a chemist's shop, you often see the flame is red. Might not a mistake be made somewhat in this way?—I think it might confuse men not accustomed to artificial lights. I think our test a very severe one, and a large number of men fail to pass. I could hardly say what percentage. The diameter of the lights used on the lines is about 6 inches. The man can see these lights a mile away. At 300 yards with a 6-inch light across he could see to stop a train well. I am speaking approximately, of course. The test at 3 yards with the disc as large as a sixpence is about equal to the 6-inch light at the distance of 24 yards. The man is wanted to see the latter at 300 yards, but we have the smaller light, which is perhaps only $\frac{1}{8}$ th of an inch. [Mr. Rix, who is colour-blind, was here called and tested by the witness, who stated that he had passed to his satisfaction.] Witness explained that with the traffic men the question is not of such importance as with drivers and firemen, who are in charge of the train and mind the brakes; the sight of the traffic men is not tested so severely as the drivers and firemen. [Witness exhibited the specimens of the glasses actually in use in the signals and in the lamps; also samples of the coloured signal flags.]

Mr. PRIESTLEY SMITH's evidence was to the following effect:—

“*Acquired Colour Blindness* differs in one important respect from congenital Colour Blindness—the congenital defect is often associated with a normal form-sense, while the acquired defect is always, or almost always, associated with more or less loss of the form-sense; that is to say, a man who has once had a normal colour-sense cannot lose it without losing more or less of his form-sense. (Leber has collected several supposed exceptions to this rule, but they are not conclusive, and are doubted even by Leber himself. ‘Graefe-Saemisch Hand-Book,’ vol. v, p. 1037.)

“In testing the visual function it is important to distinguish between the central and the more peripheral parts of the field. The centre of the retina—the macula lutea—is the part used in looking accurately at any object. The object is seen with much

greater precision when pictured on this area than when pictured on any other part of the retina. Colour-vision becomes progressively less and less acute from the centre to the periphery of the retina.

"Hence, in considering defects of vision, it is important to distinguish between those which affect the centre of the field and those which affect the more peripheral parts. A defect involving the centre implies an impairment of colour-sense and of form-sense at the point where they are most acute.

"The form-sense at the macula lutea is tested by ascertaining what is the smallest type which can be read at a given distance—according to the principle laid down by Prof. Snellen. (Snellen's Test-types.)

"The colour sense at the macula is tested by holding a small coloured object on the end of a black wire or rod at a convenient distance in front of the patient, and moving it in such a way that its image moves across his retina from the periphery to the centre. If there is a defect at the macula the colour, instead of appearing most intense at that part, appears less intense, or is lost altogether. I commonly employ a circular piece of red sealing wax on the end of a wire. I make the patient stand with his back to a window, cover one eye with his hand, and look straight at my forehead with the other. Watching that he does not move his eye, I hold the red object before him at 30 or 40 degrees to one side of his line of vision. I ask him the colour. He says 'red.' I try again at the other side, and above, and below the line of vision, with the same result. I then move the object into his line of vision, and repeat the question. If his vision is impaired at the macula he says 'it looks brown,' or 'dull,' or 'dirty,' or 'I can't see it at all.' He has a 'central scotoma'; a central area of defective vision—an 'absolute scotoma' if vision is entirely lost in this area; a 'colour scotoma' if the object is still perceived, but not its colour. A saturated colour gives the clearest indications; a pale colour is a more delicate test for slight defects, but requires better power of observation on the part of the patient. Red is practically the most effective test. When red is lost, green is lost also. Green is said to be lost before red. I cannot speak positively of this from my own observation. In order to test this point it would be necessary to choose a green and a red of precisely equal intensity—i.e., of equal white-value.

"*Central Scotoma* is caused by various affections of the optic nerve, the choroid, and the retina. I exhibit charts taken from three cases of the kind, which show the position and extent of the affected area.

"*Central Colour Scotoma due to excessive use of Tobacco*, is one of the commonest forms. I hand in some statistics which show that this condition—known as tobacco amblyopia—constitutes rather more than 1 per cent. of eye disorders in my own hospital practice; rather less than 1 per cent. in my private practice.

The scotoma has usually an oval shape, the long axis being horizontal; it includes the macula and extends as far as the optic disc.

"Persons who suffer in this way are usually what would be called heavy smokers, and they usually use strong tobacco. In a large proportion of cases there has been some mental shock or depression as an additional cause. The patient may have been a heavy smoker for many years without apparent injury; then his wife or child dies, or he loses money or employment; sleep and appetite fail, his strength is reduced, and within a few weeks the tobacco begins to take effect.

"Entire disuse of tobacco usually effects a great improvement of vision in a month or two, or even sooner; complete recovery is not uncommon. I do not know that tobacco amblyopia is commoner in seaport towns than in Birmingham. Many sailors smoke heavily, but their out-door life would probably render them less liable than the less robust inhabitants of manufacturing towns.

"In relation to the present enquiry, tobacco amblyopia is probably the most important form of acquired colour defect, for it comes on insidiously, without known cause, without pain, and without other sign of illness; it affects both eyes, and it does not prevent the man from doing rough labouring work. The patients who come to us are often still occupied in rough work; a clerk affected in like manner is quite unable to follow his occupation.

"Tobacco amblyopia would prevent a man from recognising the colour of a distant lamp. Possibly he might recognise it by viewing it indirectly, that is eccentrically, but as a matter of fact I think that such a man would always look directly at the lamp, if he could still see it at all, and would therefore fail to recognise its colour. On the other hand he would recognise the colours of large surfaces, for the retinal pictures of these would extend beyond the scotoma. I think he would recognise the colours of skeins of wool, such as are used in testing the colour sense.

"Persons suffering from tobacco amblyopia complain of bad sight; they never complain of being unable to see colours properly; they are seldom aware that they have lost the power of seeing the colour of small objects, until the fact is pointed out to them.

"*Peripheral and Eccentric Defects of Colour-sense* are common. They are present whenever the field of vision is contracted. They may co-exist with normal vision for form and colour at the centre of the retina, but in many cases central vision is impaired also. Wherever the defect be situated, the colour-sense and the form-sense are impaired simultaneously, but the sense of colour is lost before the sense of form. Green is said to be lost first of all; certainly green and red are lost before yellow and blue.

"*Neurasthenic Amblyopia* is one of the conditions in which the visual field contracts, and the colour-sense is impaired or lost. It occurs in persons suffering from nerve-exhaustion, hysteria, reflex disturbances, shock, &c.

"The function is lowered throughout the whole of the field of vision. The fields for white and the several colours are contracted or abolished. As regards area, the least active region, viz., the periphery, fails first; the most active, the centre, fails last. As regards colour-perception, the feeblest, viz., that for green, is said to fail first; the strongest, that for blue, last. I have not tested the precise order in which the different colours are lost, but I have ascertained in some cases that blue and yellow are still recognised when red and green are no longer recognised.

"These cases are characterised by undue proneness to fatigue of the visual function. The field contracts while the eye is under examination. The test is made with the registering perimeter. The limit of the field is determined in each meridian in succession, and on going round the field a second time, we find a further contraction in each meridian, and obtain a spiral line as seen in the chart exhibited. A blue glass placed before the eyes often enlarges the field and raises the acuteness of vision, presumably by cutting off the more exhausting rays. (See 'Ophthalmic Review,' May, 1884.)"

The practical outcome of the foregoing appears to be that a man who has once been found to have normal form-sense and normal colour-sense, need not be re-tested for colour so long as his form-sense remains normal; that is to say, if at any future time he can still read the normal line of Snellen's types, he is certainly not suffering from any acquired defect of colour-sense at the centre of the retina.

EYE DEPARTMENT.—QUEEN'S HOSPITAL.
Statistics of Tobacco Amblyopia.

Year.	Out Patients.	Tobacco Amblyopia.	Percentage.
1879	293	4	1.70
1880	357	4	1.12
1881	439	5	1.14
1882	574	2	.35
1883	670	6	.89
1884	1,037	13	1.25
1885	1,581	14	.88
1886	1,722	29	1.68
1887	1,770	17	.96
1888	2,004	29	1.44
1889	2,197	29	1.36
	12,644	152	= 1.20%
Last 1,500 Private Patients.			
	1,520	13	= .85%

Evidence of Mr. BAMBRIDGE, Senior Examiner of the Midland Railway.

Every applicant for employment, and every servant of the Company on promotion, is examined as to their eyesight. The apparatus used is that which I show. The tests employed are Dr. W. Thompson's tests, consisting of a series of skeins suspended over a bar, and numbered with numbers which have reference to the colour. Three test skeins are used as standard skeins, the first a blue-green, the second a rose colour, and the third an ordinary scarlet. A candidate is required to match with the first test skein the skeins on the suspended bar, which comprise greens, greys, drabs, pinks, slate colour, and other colours corresponding to Holmgren's colours. (The tests were practically carried out after the Holmgren method.) The tests are carried out by daylight, though gaslight tests are sometimes employed. Doubtful cases are re-tested by Holmgren's plan. This method of testing has been in force for eight or nine years; before that the Army test was employed. The witness believed that the method now employed was very perfect. Should a signalman fall ill he is always tested before he is allowed to rejoin his post with the ordinary signals. In reference to colour-blindness produced by disease, he never saw a man who passed once fail on a further examination. It is quite possible that a man may fail in the wool test who rightly reads signals. The gaslight test takes place in a covered corridor with green and red lights; but, in addition to this test of signalmen, the wool test must also be passed. The position of the skeins of wool on the bar is not altered, and in case of doubt as to collusion the Holmgren test is adopted. About 2½ per cent. of the whole who are examined fail. Sometimes a man may be allowed a second chance of examination if it appears that he fails through ignorance, but he never found that practice enabled a really colour-blind person to pass in a second examination. A man is always examined for colour-blindness after an absence due to an accident in case any alteration in his colour-vision should have occurred. As before said, a man is tested at every stage of promotion, and every applicant has to come to Derby for this purpose. With the aid of assistants, but under the witness's personal supervision, between 1,500 and 2,000 candidates for employment are examined each year, and in all 2,500 if old hands are included. Candidates are also examined for form, as in the Army test. The method is by means of dots separated by intervals equal to their diameters.

A distant signal is often three-quarters of a mile away from the signal box, and the signalman has to see if the arm works in the day time, or if the proper light is shown at night. An engine driver must see a signal about half-a-mile off in order that he may stop his train if necessary. Witness never heard of a case of an engine driver reporting a fireman for want of colour perception. Cases have been heard of in which the colour of light has been mistaken, and in such cases the man would be at

once suspended until he were re-tested. After a candidate has been tested at the office, he is sent to a medical man, and it has occurred that he has rejected a man who has passed the test. In such a case the man is tested for colour at the office again, and if he again passes, which he always does, he is not rejected for colour defect. All testing is done under the immediate supervision of the witness. Should a candidate show a slowness in selecting colours to match the test skeins, he would be reported as hesitating, and though the defect in vision might be trifling, he would be considered as unsuitable for an engine driver or for a signal man. Of the two tests, the witness preferred the heap (Holmgren's) test as the better, but it took longer to carry out than the bar (Thompson's) test, the latter only occupying a couple of minutes for each candidate.

The witness examined Mr. Rix, who is colour-blind, for his colour perceptions, and said he should not have passed him. He gave the following table of statistics to the Committee:—

Statistics respecting Colour-Blind Persons.

Half-year ending	Number of Candidates Examined.	Number found to have Imperfect Colour Perception.	Percentage.
June, 1884	722	20	2·77
Dec., „	1,019	39	3·82
June, 1885	551	17	3·08
Dec., „	922	37	4·01
June, 1886	557	8	1·43
Dec., „	521	12	2·30
June, 1887	642	10	1·55
Dec., „	520	12	2·30
June, 1888	625	2	0·32
Dec., „	726	13	1·79
June, 1889	637	6	0·94
Dec., „	1,035	19	1·83
Average per annum..	1,413	32·5	2·18

Evidence of Mr. T. H. BICKERTON, of Liverpool.

I do not know that I have got much more to say than I have already said in my pamphlets, although a few new facts have come under my observation.

The main point I have had in writing these pamphlets has been to point out to the Board of Trade in particular, and to the public in general, the great dangers incurred by the employment of colour-blind men, and of defective-sighted men, in positions

where the correct interpretation of coloured lights is essential to the safe navigation of vessels.

I have shown, and I think conclusively, the great difficulty there has been in the past in getting the Board of Trade to recognise these dangers, and that when at last they did recognise the dangers, they instituted methods of testing for colour-blindness which are not efficient, this being shown by the facts that these said methods, while they in very many cases allow colour-blind men to pass, in some cases cause the rejection of men as colour-blind who have a perfect colour sense. I have also shown that while the methods of testing are inefficient for the purpose intended, viz., the detection of colour-blindness, the regulations dealing with these colour-blind men when so detected are thoroughly bad. Colour-blind officers are granted the higher certificate, which is simply endorsed "This officer has failed in colours;" and the fact that he is colour-blind is no bar to his continuing in a responsible position. In the case of men applying for a Second Mate's Certificate, it is true he does not now receive his certificate, but he is at liberty to continue his profession. So far as the Board of Trade regulations go, colour-blind pilots, colour-blind "look-outs," colour-blind A.B.'s, and colour-blind apprentices are quite competent to assist in the navigation of ships, and may remain sailors to the end of their days. I believe that no regulations, however elaborate, with the object of preventing collisions at sea, and of preventing loss of life at sea, can be successful so long as men who have not good distant sight, and men who are colour-blind, are tolerated in the Mercantile Marine. Again, improvement in the methods of testing alone will not remedy the evils nor do away with the great hardships entailed on colour-blind men. At the present time a compulsory colour-test is only applied to those men wishing to advance themselves, and thus it is only after years of labour that their defect is discovered. To remedy the evils and the hardships, it is essential that a colour test be employed at the very commencement, and those who are colour-blind should be stopped before they begin the sea life. At the present time there is no test, and of a total of 956 boys who were being brought up for the sea life on training ships, I found thirty-four who were colour-blind. These were boys who were going to be sailors, and every sailor has responsibilities with regard to "look-out" lights, and I have proof that the large majority of these boys went to sea. I am told that the captains of reformatory training ships are compelled to accept boys even though they know them to be colour-blind.

The CHAIRMAN: Your first point is, that all these boys should be prevented from going to sea?

The WITNESS: Yes. The Board of Trade cannot settle this question by improving their tests unless they at the same time prevent colour-blind boys entering the Service. It seems to me the action of the Board of Trade all through has been inexplicable

At first they would not believe in the existence of colour-blindness; then when the dangers of colour-blindness could not be denied, they said the number of colour-blind cases were very small; and now they say the number of cases are so numerous that it would cause great hardship to rid the Service of them all. At the present moment no care whatever is taken to prevent colour-blind boys from being brought up to the sea life. Some three or four years ago I examined the boys of the training ships *Conway*, *Albar*, *Clarence*, *Indefatigable*, and *Clio*, the first four ships being in the River Mersey, the latter in the Menai Straits.

On the *Conway*, out of 154 boys 2 were colour-blind. One, aged 14, had been on board two years; the other, aged 13½, had been there eighteen months. Both were fond of the sea; both were unaware of their defect; and both, on their friends being informed of the matter, were removed from the ship. On the *Albar* there were 4 colour-blind out of 148 boys; on the *Indefatigable*, 12 out of 238; on the *Clarence*, 7 out of 158; and on the *Clio*, 9 were colour-blind out of 258 on board.

On these five vessels, therefore, there were at the time of my examination a total of thirty-four colour-blind boys being specially trained to a profession which they were physically and morally unfitted to enter. In addition to these, of 200 boys in the Seamen's Orphanage eight were colour-blind, and it is purely a matter of chance whether the boys have gone to sea or not.

Question.—Do you know if there is any examination in the case of the boys on the *Britannia*?

The WITNESS: I do not, but I should think there is. There is a careful examination as to form-vision, and they reject all boys who have not perfect vision of both eyes. Since the two colour-blind boys were discovered on the *Conway*, the Committee of that vessel have, I understand, insisted that every boy joining the ship shall bring a certificate stating that he is not colour-blind. I do not know if they are particular as to who gives the certificate.

Question.—Can you make any numerical statement as to persons on the seas whom you regard as unfit for their duties?

The WITNESS: I am aware of (a) eleven colour-blind men who were bound apprentices, and who at the time I was consulted had been at sea for periods varying from four and a half to eight years; (b) of four colour-blind able seamen whose years of service were respectively thirty-five years, twenty-one years, twelve years, fourth unknown; (c) of seven officers holding high and responsible positions, the length of whose services were respectively twenty-six years, eleven years, six years, ten years, twenty years, twenty years, thirty years, making a total of twenty-two colour-blind sailors. (In addition to these actual sailors, there are the thirty-four colour-blind boys, the majority of whom are now at sea, unless they are dead or left the service.) Some were obliged compulsorily to give up their

positions as officers owing to their being discharged by the owners. Whether they have gone to sea in the employ of less particular companies, I cannot say. I can only state positively that four of the twenty-two have not gone to sea. One of these four is the case of Captain John Smith, whose case has been brought prominently before the notice of Sir Baden Powell, who wrote to Sir G. G. Stokes about the poor fellow. The letter written by Capt. Smith, and published in the *Shipping and Mercantile Gazette and Lloyd's List*, dated 13th August, 1889, explains itself:—"On the 19th of June you were good enough to insert in your valuable paper a letter written by me on colour-blindness, and I am pleased to find that my letter and your article commenting on same has attracted considerable interest, notably by the Board of Trade. My object in again troubling you is to impress upon the Board of Trade the necessity for a more perfect means of testing sight. I have lost my position as chief officer in the employ of one of the best and most influential firms in this port, in whose service I had been for a period of six and a half years, and with a near prospect of command, through not being able to conform to owners' rule and produce a colour test certificate from their examiner, who, on the contrary, styled me colour-blind. I, however, doubted the accuracy of the report, and presented myself to an oculist, but found, alas! the Company's examiner's report too true. Now, I call this a very painful case, after being thrice passed by the Board of Trade for Second, First, and Master's Certificates. If the Board of Trade examination on any of these occasions had been true, I would have directed my energies towards another way other than the sea to obtain my livelihood. I may say that the defect in my vision has been, in the oculist's opinion, there from birth. I am now, morally and conscientiously, incapable of performing the duties of an officer on board ship at sea, though my Certificate bears no endorsement of any kind by the Board of Trade. Many owners I know do not require their officers to pass the colour-blind test, being satisfied with the Board of Trade Certificate. But I should think my case ought to be a warning to shipowners not to place reliance on the present Board of Trade test. My colour-blindness has destroyed my means of livelihood, and I fearlessly say that the Government test of sight is to blame for this. I am informed that I cannot claim compensation from the Board of Trade, because they have not interfered with my Certificate; but suppose I follow my avocation and get into collision through my defect, what then? and who would be to blame? I am a young man of thirty-three, and I have a wife and family depending upon me, and my position at present is very distressing. The best part of my life (Capt. Smith has been at sea for twenty years) has been passed in useless toil. My energies and prospects for the future have been unrewarded and blighted through no fault of my own, but through the lax and imperfect way in which I was examined and passed in sight by

the test that was adopted by the Board of Trade throughout the whole of my examinations."

When I first saw this gentleman on May 11th, 1889, a more hearty man than he appeared could not be. He had been getting £9 a month, and a bonus of £1 from his Company. The Company, on dismissing him from his ship, behaved very kindly, giving him shore employment at about £5 a month. But the loss of his situation, the having to give up the sea, and the destruction of his hopes so preyed upon his mind and body, that in May last he became the victim of acute phthisis, and died.

Up to the day of his dismissal he had not had a day's illness, nor had he had occasion to consult a medical man. The Board of Trade were well aware of the case, for on June 19th, after his letter had appeared in the press, he was sent for by the Liverpool Board of Trade, and asked if he was the writer of the letter, and his object in writing it; and, when he said it was in order to get employment, he was told to the effect that, as the Board of Trade had not interfered with his certificate, he had no claim upon them, and that if shipowners chose to make laws for themselves, it had nothing to do with them, and did not prevent him going again to sea, as he could go to other companies. It must not be thought this is an isolated case. It is now no uncommon thing in Liverpool to hear of officers being dismissed for colour-blindness who have held, in some cases for years, lucrative and responsible appointments on board ship. Everyone will admit the justice of these dismissals, for upon the correct colour-vision of the officer on watch depends the safety of the ship, and, in many cases, the lives of hundreds of helpless passengers, and property to the extent of hundreds of thousands of pounds, but everyone will at the same time admit the hardship—nay more, the injustice—done these men by the use of bad Government tests and regulations. This brings me to another point, that many of the shipowners of Liverpool will not take a Board of Trade certificate now. Up to the time I wrote my second pamphlet the Liverpool shipowners believed that the Board of Trade certificate was a positive proof that an officer was not colour-blind. Now many of them refuse to take it. They do not test the men themselves. Many of them send their officers to medical men or to opticians, or ask them to again go to the Board of Trade, and I may here mention that sailors have a considerable objection to being tested by opticians; and I have been told of a case where a sailor, on being rejected by a surgeon attached to an Atlantic liner, remarked, he "didn't see why he should not go to sea, because a common ship's doctor said he was colour-blind." These men have the Board of Trade certificates already, but since I pointed out the defects in the Board of Trade tests, many of the owners of the large Atlantic passenger steamers insist on a re-examination of their officers' colour-sight and form-sight.

I think there should be an efficient examination in the first instance. No improvement in the mode of testing can be satis-

factory unless it is applied at the threshold of the sailor's career, and not, as at present, when about to obtain the reward of his years of labour. Before an apprentice or man be allowed to put his foot on board ship as a sailor, he should be compelled to produce to the Captain or Shipping Clerk a certificate of good colour-sight. The matter entails no difficulty. At the present time a sailor is obliged to keep by him his various certificates of discharge, it would be no hardship for him to keep a colour certificate also.

The CHAIRMAN: How can we give a numerical value to your observations? You know of several cases of officers who are colour-blind, and are sailing the seas, to what extent can you give percentages?

The WITNESS: It is difficult to do this, but we may presume that the percentage of congenital colour-blindness among sailors is the same as that among any other community of males, and by taking the average of the percentages given by three reliable authorities:—

Holmgren examined	32,165 men	—1,019 colour-blind,	3.168 per cent
Joy Jeffries	" 10,387 "	431 "	4.149 "
London Com.	" 14,846 "	617 "	4.156 "

this is found to be 3.824. By the census of 1881, the number of sailors in the Mercantile Marine Service in England was 95,093; in Scotland, 14,143, and in Ireland, 10,886; making a total of 120,122; and this does not include such men as pilots, canal or lighter men. Calculating 3.824 per cent. of this number to be colour-blind, we have a total of 4,593 men holding at the present time positions in which the correct interpretation of coloured lights is essential.

I am not making allowance for those rejected. But I might call attention to the great variations in the Board of Trade percentages of rejections, which render their report unreliable. In the official report, published in February, 1885, it is stated 123 men were colour-blind out of 21,720 examined, this giving the percentage of .586, and a careful study of this report will show that thirty-one out of eighty-five colour-blind men eventually were granted unendorsed licenses. But the public attention called to this question has raised the percentage, for we are told, in the report of 1888, that between the months of January and May, no fewer than 320 sailors were examined by the Superintendent of the Mercantile Marine, at Tilbury Docks, and among them sixteen, or five per cent. were found unable to discriminate red and green in the degree requisite for safe navigation. This percentage one may positively state is as ridiculously high as the former quoted is ridiculously low. Something therefore must be wrong, either with the tests themselves, or with the way in which they are applied.

All who have consulted me have done so on account of their colour-blindness. A very considerable number of these came to me because they did not believe they were colour-blind. The defect

had been found out accidentally, or owing to their being compelled by their employers to undergo a re-examination, as to their colour-vision by the Board of Trade or by opticians. I examined them for colour-blindness by all ordinary tests.

I use a good many, but Holmgren's is the one that I trust fully. I have not kept records of those who were not colour-blind, but they were very few, for there could be no reason for a man who was not colour-blind coming to see me. I can, however, remember two cases, and one of them whose case is fully quoted in Pamphlet No. 2, page 7, shows clearly that by the present Board of Trade testing a man who is not colour-blind may be, by their tests, rejected as colour-blind.

The CHAIRMAN: Taking any one company, can you form any idea as to how many officers in their employ are colour-blind?

The WITNESS: No, because I do not examine for any company; but Dr. Hodgson, of Bootle, who examines for the Cunard Company, told me he rejected five out of 120 officers in the employ of the Cunard Company for diseases of the eyes. This company, long before the Board of Trade took up this matter of the sailors' eye-sight, recognised the grave responsibility resting with them in the selection of men (look-outs and officers) for a duty which they considered of paramount importance. For this they deserve every credit, and it is no doubt one reason of the freedom this company has had from disaster (*vide* Pamphlet 3, page 12).

The CHAIRMAN: Have you details of the diseases of the rejected men?

The WITNESS: No, but the same doctor quoted the case of an officer who could not tell the colour of his ship's funnels, and did not know that the fluid issuing from his nose on one occasion was blood, until told by the bystanders.

The CHAIRMAN: The point you want to bring before the Committee is that a test for colour-vision should be instituted at the commencement?

The WITNESS: Yes, at the very commencement, and those who have not perfect colour sight, and also good distant sight, should not be allowed legally to enter the service at all.

The CHAIRMAN: You wish further to point out that the methods of testing by the Board of Trade are wholly insufficient?

The WITNESS: Yes.

The CHAIRMAN: And that although you are not able to make a numerical statement, you are convinced there are many persons now in the Mercantile Service who are colour-blind?

The WITNESS: Yes.

The CHAIRMAN: There are a number of training institutions for the poor where destitute boys are sent, I believe?

The WITNESS: Yes; the *Indefatigable*, *Akbar*, *Clio*, *Clarence*. To the three latter vessels boys brought before magistrates for vagrancy are sent without any reference being made as to their fitness for the sea life. Everybody to be employed as

sailors should be examined as to their colour-vision. I do not include firemen and stokers. At the present time individual ship-owners have the men in their employ tested; but this is of little avail unless all men in every company are tested, for it takes two ships to make a collision.

The CHAIRMAN: Have you ever thought whether it is feasible by altering the coloured signals, say by substituting a flashing light as in the army, the difficulty might be got over?

The WITNESS: Yes, I have thought of it, but I believe it to be impracticable. The shipping men themselves say so. In this question of coloured light there is one eminent gentleman who has, in my opinion, done much harm. Admiral Colomb has been a great power in preventing this subject of colour-blindness receiving the attention it deserves. I have in Pamphlet 2, page 11, given my reasons for believing the means recommended by "Select Committees for the Prevention of Loss of Life at Sea" are and must remain futile so long as the very essential of safety, namely, perfect eyesight on the part of officers and men, is ignored. Admiral Colomb thinks differently, but, as I believe, wrongly, and I would have no hesitation in taking the popular vote on the point between us. In the course of an able paper delivered by him on the subject of the Washington Maritime Conference, at the Society of Arts, and reported in *The Times* of March 28th, 1890, he made the following remark:—

"As to the qualifications for officers and seamen, the Conference (Washington) dealt wholly with the question of colour-blindness on account of its danger with reference to the red and green side lights. He never knew himself a case of collision where colour-blindness was in question. The statements were generally perfectly clear that wrong helm was given deliberately in the face of the colour seen, and as no authoritative teaching had existed to show that it mattered what colour was seen so long as danger was denoted, he had never been able to lay stress on the colour-blind question."

Mr. Baden Powell, R.N.R., who followed in debate declared "that in all cases of collision at sea there was no default of the rule of the road at sea, but they generally arose from negligence. The rule of the road at sea was perfectly well understood by intelligent men, and it was the 'lubbers' and the careless who did not act according to it."

Admiral de Horsey considered "collisions at sea were caused principally by three faults—a bad look-out, ignorance of the rules, and neglect of the rules."

In his reply Admiral Colomb "expressed his opinion that collisions at night occurred through the helm being ported to the green light, and starboarded to the red; and he could not agree that the collisions occurred wholly through negligence, for he thought that they largely occurred because our seamen were not taught what they should do, and the collisions occurred through ignorance."

Now I say that there are a number of well authenticated cases where disaster due to colour-blindness and to defective sight actually occurred, or was narrowly averted; and it is surprising Admiral Colomb does not know of them. I would also ask whether Admiral Colomb knows of a single case out of the thousands that have occurred where, after collision, the colour sight of the officers and men was tested by an expert. Would it not be as well if Admiral Colomb were to eliminate this cause before denouncing it? One might have thought that, as in most shipping enquiries, the evidence as to the colour of the lights, and as to the distance at which they were first seen, is bewildering in its contrariness, the first step towards a solution would be to examine on the spot the far sight and colour sight of the witness; but those who adjudicate at these enquiries think differently, and take it for granted that the witnesses coming before them have perfect far sight and perfect colour sight. It is my opinion that if the eyesight of sailors on colliding vessels were tested in Court, we should find that the cause was in many cases neither ignorance nor negligence, nor due to "lubbars," but that it would be found in the colour-blindness or defective sight of the officers and men on watch.

Capt. ABNEY thought Admiral Colomb must have realised the fact that there are mistakes as to the colours, and was a man very much open to conviction, and ready to adopt improvements. He could not think he was antagonistic to anything in the way of advance.

The WITNESS: In opposition to the opinion of these eminent gentlemen, I will quote the opinion, in which I fully agree, expressed by a gentleman who wrote to the *Liverpool Daily Post* in the following terms:—

"Is it reasonable to believe that steady married seamen with families depending on them, and who have had years of experience, suddenly lose all judgment and common sense, and steer their vessels on clear nights, sometimes in broad daylight, so as to deliberately ram each other, thereby losing their lives and ships, and the lives of the passengers? Surely not. In none of the other professions or callings can we find anything approaching a parallel case; therefore, in some cases their eyesight must be defective."

If Admiral Colomb would only take the trouble to examine personally a colour-blind officer, I feel sure that this subject would have in him a distinguished convert and an able and powerful advocate.

The CHAIRMAN: Have you any special evidence to give as to accidents?

The WITNESS: Yes, in Pamphlets 1, 2, and 3 I have related many cases of accidents due both to colour-blindness and to defective sight on the part of those in charge of the vessels. The Liverpool Board of Trade use the ordinary Board of Trade tests.

The CHAIRMAN: What authority has the Liverpool Board of Trade? Is it simply limited to Liverpool?

The WITNESS: Yes, the powers of the Central Board of Trade are given over to the Liverpool Board for Liverpool.

Question.—Will you give us your practical experience with regard to different methods of testing?

The WITNESS: I have very little hesitation in saying that all tests requiring a man to name colours are defective. Practically, that brings them down to Holmgren's, which is the simplest, and, for ignorant men, the best one. I consider that test perfectly trustworthy, and it has one great advantage—it can be applied irrespective of nationality.

The CHAIRMAN: As a matter of practical experience, about what time do you find it takes in using Holmgren's test?

The WITNESS: I calculate about 40 boys an hour, or 100 girls in the same time. The time taken depends a great deal upon the social standing of the children. At Eton or Harrow it would be very different to that at reformatory schools, where perhaps only thirty boys could be examined in an hour, as they are so ignorant that a test has to be explained to them over and over again in order that ignorance may not be mistaken for colour-blindness. I am acquainted with Professor Grossman's test, and I think it a test for experimental purposes, but not for practical use. Captain Smith, of whom I have already spoken, passed it without difficulty. He was examined by the Board of Trade card test and lanterns. He was then asked by Sir George Powell to see Dr. Grossman, and Captain Smith told me he named the letters rightly. I tested him on two or three occasions with Dr. Grossman's test, and he never made a mistake.

Question.—Did Dr. Grossman supply the test you used?

The WITNESS: I got it from the optician from whom he said it might be obtained. In many cases it would be difficult to reject with this test, although feeling sure the candidate was defective. An educated colour-blind man would get through. There is also the disadvantage that it takes considerable time to apply.

The CHAIRMAN: What was the nature of Captain Smith's colour-blindness?

The WITNESS: I do not for the moment remember. I do not find the great distinction which is laid down between the different kinds of colour-blindness. The one class appears to run into the other.

I think different classes do exist, and in great number.

I have not examined cases with regard to the shortening or non-shortening of the spectrum.

The CHAIRMAN: You have no suggestion to make with regard to tests?

The WITNESS: None, except that I pin my faith to Holmgren's test applied by an expert examiner, and carried out according to Holmgren's instructions.

In connection with this test I should like to hand in a letter which I received lately from Mr. Clement E. Stretton, C.E., of the Associated Society of Locomotive Engineers and Firemen:—

“40, Saxe-Coburg Street,
“Leicester,
“December 21st, 1889.

“DEAR SIR,—I am always glad to read a letter on the eyesight question, as I trust it will all lead to something being done to avoid that which may soon turn to a strike against ‘dots and wool.’ In order to save the men their situations the Railway Societies are having the men taught in wool shops with first-rate results.

‘The present tests are useless for railway men, and very unfairly applied when required to get rid of the men.

“The *Mechanical World* and *Invention* of to-day each have important information upon the subject.

“I would strongly advise you to apply to Mr. Harford, Railway Servants’ Society, 55, Colebrooke Row, London, N., for the practical side of the question.

“Yours truly,
“CLEMENT E. STRETTON.”

The complaint which Mr. Stretton makes as to the unfair way in which railway men are treated is no doubt grounded on just cause, but he is in error when he attacks, as he has on many occasions done, Holmgren’s test, which has with reason been accepted as a reliable one by those more competent to judge. The “dot and wool” test of the Railway Companies is not the wool test of Holmgren, and the fact, as stated by Mr. Stretton, viz., that the railway men can be educated to pass the test is, if any were required, positive proof that the test applied to them is not Holmgren’s. It would, however, appear that there is cause to believe that the men are badly treated, as the following letter will show; and until Holmgren’s test becomes the official test, and is applied by those who understand its use, and who are in an independent position, the friction which is at present felt is likely to continue:—

“Amalgamated Society of Railway Servants,
“Head Offices, 386, City Road, London,
“March, 1887.

“DEAR SIR,—At the last Meeting of the Executive Committee the testing of the eyesight of drivers, firemen, guards, signalmen, and other servants of the various Railway Companies was considered, and from the facts submitted it was felt that the usual tests were often most unfairly applied, more especially in the case of the older servants, and that, in consequence, men were being reduced or removed from the service under the plea of defective sight. From this there being no appeal, the Executive Committee considered that the tests were being used so as to

give a pretext for getting rid of men who have grown grey in the service, and whose lengthened experience and faithful servitude should entitle them to some consideration.

“In order, then, that men so tested may have the opinion of their fellow members as to whether their sight is defective, I am instructed to enclose you a card used for testing sight with which members may test each other, and in the event of the unfair tests being used by the Companies’ officials, a reliable protest can then be made, backed up by the verdict of the branch, which would, of course, submit any member said to have defective sight to the usual tests in order to satisfy itself, before expressing an opinion.

“It may also be found advantageous to frequently use it when no such cases require to be decided, so that members may be familiar with its use, and so be prepared to undergo the examination whenever called upon.

“Printed instructions for using the card will be found on its back.

“I am, dear Sir,
“Yours faithfully,
EDWARD HARFORD,
“General Secretary.

“To the Branch Secretary.”

The CHAIRMAN: Have you any knowledge as to what the test was that was issued with this circular?

The WITNESS: Yes, the ordinary railway test card, having printed on it the small square dots and spaces, and the colours red, green, yellow, and blue; and this test is an absolutely useless one.

The CHAIRMAN: You think it impossible to get a colour-blind through Holmgren’s test?

The WITNESS: A congenital colour-blind. Yes, impossible.

The CHAIRMAN: Have you any special evidence to give as to accidents?

The WITNESS: I have given cases in my pamphlets. The first case is to be found in the Annual Report of the Supervising Inspector-General of Steam-boats, to the Secretary of the Treasury, dated Washington, 1880, and reads as follows:—

“On the the night of the 5th July, 1875, there was a collision near Norfolk, Virginia, between the steam-tug *Lumberman*, and the steam-ship *Isaac Bell*, the former vessel bound to, and the latter from, Norfolk. The accident occurred about 9 p.m. on an ordinary clear night under circumstances which, until recently, seemed more or less mysterious. The master of the steamer and all his officers made oath that at the time signals were made to the tug, the latter was from one to two points on the steamer’s starboard bow, and consequently the steamer’s green light only was visible to the approaching vessel. Yet the master of the tug, whose statement was unsupported by any other testimony, asserted that the steamer’s red light was exhibited and signalled

accordingly. The discrepancy in the statement was so great that many persons uncharitably charged the master of the tug with being intoxicated, although no evidence was offered in support of the charge. By this accident ten persons lost their lives. Upon a visual examination of this officer under the rules during the past summer, and during which time there had been no question as to sight by the Sergeant of the Marine Hospital at Norfolk, he was found to be colour-blind, two examinations having been accorded him, with an interval of ten days between them."

A second case is mentioned in the *Shipping and Mercantile Gazette and Lloyd's List*, dated 29th June, 1881:—

"The pilot of the *City of Austin*, which was lost in the harbour of Fernandia, Florida, last April, is proved to be colour-blind. In this way it would appear he mistook the buoys, and his mistake cost the owners 200,000 dollars (£40,000). An examination showed that at a distance of more than six feet he could not distinguish one colour from another. The physicians attribute the defect to an excessive use of tobacco. The services of the marine surgeons were tendered to the local authorities without fee two years ago, but were declined."

A third case is recounted in a letter from Messrs. Macintyre & Co., Liverpool, shipowners:—

"Our ship *Carbet Castle* collided in the South Channel, bound from Dundee to Cardiff, in 1879, with the *T. H. Ramien*, due, as far as we can make out, to the colour-blindness, or short-sightedness of the chief officer."

The following account is written by Captain Coburn, who was for many years in the employ of Messrs. Leach, Harrison and Forwood, of Liverpool, and is to be found in the *Mercantile Marine Reporter*, vol. xiv, No. 162:—

"The steamer *Neera* was on a voyage from Liverpool to Alexandria. One night, shortly after passing Gibraltar, at about 10.30 p.m., I went on the bridge, which was then in charge of the third officer, a man of about 45 years of age, and who up to that time I had supposed to be a trustworthy officer, and competent in every way. I walked up and down the bridge until about 11 p.m., when the third officer almost simultaneously saw a light about two points on the starboard bow. I at once saw it was a green light, and knew that no action was called for. To my surprise, the third officer called out to the man at the wheel 'port,' which he was about to do, when I countermanded the order, and told him to steady his helm, which he did, and we passed the other steamer safely about half a mile apart. I at once asked the third officer why he had ported his helm to a green light on the starboard bow, but he insisted it was a red light which he had first seen. I tried him repeatedly after this, and although he sometimes gave a correct description of the colour of the light, he was as often incorrect, and it was evidently all guess work. On my return, I applied to have him removed from the ship, as

he was, in my opinion, quite unfit to have charge of the deck at night, and this application was granted. After this occurrence I always, when taking a strange officer to sea, remained on the bridge with him at night until I had tested his ability to distinguish colours. I cannot imagine anything more dangerous, or more likely to lead to fatal accidents than a colour-blind man on a steamer's bridge."

A similar experience is thus related by Captain Heasley, of Liverpool:—

"After passing through the Straits of Gibraltar, the second officer, who had charge of the deck, gave the order to 'port,' much to my astonishment, for the lights to be seen about a point on the starboard bow were a masthead and green light, but he maintained that it was a masthead and red, and not until both ships were nearly abreast, would he acknowledge his mistake. I may add that during the rest of the voyage I never saw him making the same mistake. As a practical seaman, I consider a great many accidents arise from colour-blindness."

In the collision which occurred in February, 1889, between the steamship *Nereid* and the sailing-vessel *Killochan*, the vessels had had each other in sight for at least two miles, and it was a perfectly clear night. *The Times*, in commenting on this disaster, remarks, February 5th, 1889, that "all inquiries respecting the cause of disaster lead to the same conclusion, that it was due to one of those astounding errors of judgment on the part of one or other of the navigators, which seemed to deprive all attempts at reasonable excuse. Each blames the other."

As we know that there are many colour-blind men holding officer's certificates, it will not be surprising if it were found that the officer in charge of the steamship *Nereid* was colour-blind. The explanation of the accident would be similar to that first quoted, namely, that he mistook the green light for a red one, and ported in order to go, as he erroneously would think, astern of the *Killochan*.

So long as colour-blind men are tolerated in the Mercantile Service, these accidents will occur.

Question.—But could not many of the people on board have seen how these accidents occurred?

Yes, and the evidence in these cases is always conflicting. Everybody will remember the loss of the *Oregon*. It was said to have been run into by a coal boat. The evidence was contradictory, the light seen being described as white, red, and green.

But the idea of examining the men's colour-sight was never thought of. In the following case the steamer *Toronto* on the night of January 18th, 1888, ran down the Norwegian barque *Freidis* in the Irish Channel, on which occasion thirteen lives were lost. The evidence given at the Board of Trade enquiry as to the lights seen may be briefly summed up as follows:—The captain, the mate, and the quartermaster saw first a red light and then a green one. The look-out man saw no red light, only

the green light. Asked if he was colour-blind, he replied that he was not, and that he had never made a mistake in reporting the colour of a light; and, in answer to the question as to what in his opinion was the cause of the collision, he had no hesitation in stating that it was owing to his own captain porting his helm. In a letter published and commented upon in the leading Liverpool shipping paper, the *Journal of Commerce*, referring to this case, it is remarked that "the negative evidence of the look-out man that he did not see the red light cannot weigh against the positive evidence of the captain, two officers, and the quartermaster that they did see it, and it has yet to be ascertained why it was not seen by him." But the Court chose to take the look-out man's statement as against that of the officers. The officers of a ship being considered the responsible men navigating a ship are therefore tested for colour-blindness by the Board of Trade, but the Board of Trade do not admit that the look-out men are responsible. They argue in this way:—

It is not for the look-out men to say what the colour of lights are they see. They merely have to report that there is a light, and it is left to the officers to say what that light is; but when collision cases come into Court the Judges invariably ask the "look-out" as to the colour of the light seen, and as often as not take the word of the irresponsible "look-out" against that of the responsible officer, who is supposed to do the best for his Company, and who is also on his trial.

Mr. Bickerton subsequently communicated the following results of an examination for colour-blindness that he held:—

"I examined again on Monday and Tuesday last the boys of the Seamen's Orphanage in order to obtain some cases for a lecture. The results of the two days' examination were most curious—

First day—91 boys examined	..	1 colour-blind.
Second day—44 " "	..	5 typical blind.
		or 6 colour-blind in 135.

Total number of boys 225; but I had no time to examine the remainder. On examining the same institution five years ago there were 8 colour-blind out of 200. All the children are, as the name of the Institution implies, the sons of sailors. That fact, in chief, is of interest when the hereditary quality is taken into consideration."

Evidence of Mr. E. NETTLESHIP.

Prof. FOSTER: You have kindly consented to put the information you possess concerning Colour-vision at the disposal of the Committee, and we must leave it to you to decide the points upon which you will give evidence; but there is one class of cases we should particularly like to know something about, namely, those of scotoma from diseases of the optic nerve?

The WITNESS: It generally affects both eyes, and causes a lowering, but seldom complete loss, of the functions of the central part of the visual field. Except in very severe cases perception of black and white remains, but there is, I believe, always a disproportionate lowering of perception of colours over that area. I believe the usual form it takes is blindness to the complementary colours—red and green.

For detecting the presence, and roughly estimating the size and density, of the defective area (scotoma), it is enough to use a small piece of coloured paper on the end of a stick or a pen; the coloured piece should vary in diameter from 5 mm. or less, up to 25 mm. or more, according to the severity of the case; the more the sensibility to red, *e.g.*, is lowered the larger must the retinal image be, *i.e.*, the greater the number of units excited, in order that the sensation of red may be produced; also the greater the defect the brighter must the colour be. For accurately mapping the scotoma of course the perimeter must be used. As the loss of colour perception on the greater part of the defective island, and often over the whole of it, is only partial, the size of the scotoma and its exact outline, like the size and exact outline of the normal field for any colour, vary according to the size and quality of the colour used, and also to some extent with practice and attention on the patient's part.

I usually take red first, because any defect in that is most easily apparent; it is not so easy to get a pure green, and many people are uncertain between blue and green, or do not know the names. In very slight cases, however, we sometimes use a pale green in preference. The green I use is as pure a light green as I can get. "Emerald green" conveys to me the idea of a bluish-green, but perhaps erroneously. Light-green baize would be the colour, I should think.

Question—Could you describe the green you mean in wave-length?—I have no knowledge of colour expressed in terms of wave-length.

The detection of the scotoma depends in a certain degree on the luminosity of the test-colour employed; *cat. par.*, the lower the saturation of the coloured spot, and the smaller the diameter of the coloured spot, the more easily is the defect perceived (*see* answer to a previous question).

I do not test with mixed colours: for instance, purple I found unsatisfactory, except in slight cases of tobacco amblyopia, where you must either take an extremely small spot of pure colour or a larger spot of carefully mixed colour. Such patients will sometimes say mauve is red. Something depends on the patient's training and intelligence. I had a case of central scotoma from tobacco smoking in a man who had been accustomed to deal in artist's pigments; he recognised every colour, pure and mixed, in spots of various sizes, till I tried a dark sort of mauve, which appeared to him blue or bluish in the centre of the field. He said that the only commercial colour with which he had had any difficulty was

"small." [The witness here handed in a number of charts illustrative of cases of tobacco amblyopia, and atrophy of the optic nerves, and explained with reference to them.]

Question—They do not lose the sense of form, only the colour?—The test is used only for its colour. The form of the spot is not spoken of, and is of no importance.

Question—Is not the defect of Colour-vision generally accompanied by defect of Form-vision?—Yes, always. I have never seen a case in which the loss has been entirely a colour loss. The form loss (loss of acuteness of vision at the centre of the field) is always recorded first. Speaking broadly, the loss of form-sense, as it is commonly tested, *i.e.*, by black letters on a white ground, is about proportionate to the loss of colour-sense at the centre of the field. One commonly records the form-sense however, only at the exact centre of the field, whilst in the cases of central (or approximately central) scotoma, one tests the loss of colour-perception over an area extending several degrees from the centre in every direction. If the scotoma area be represented as a cloud, we shall have to say that in different cases the total area of the cloud varies, as well as its average density, and that its nucleus or densest spot, though always very near to the exact centre of the field, seldom coincides precisely with that point, being usually 2 or 3 degrees to its outer (temporal) side, sometimes inclined upwards, sometimes downwards. The cloud usually forms an oval, extending further into the outer than the inner part of the field, and frequently including the blind spot. If the cloud be very large it may be co-extensive with the field for green or for red, and then those colours will not be recognised anywhere; but in the ordinary tobacco cases the cloud is smaller than the red field, if not smaller than the green field, so that a red-perceiving zone is left of greater or less width and perfection. (Several of the charts illustrate these various points.) In the cases to which I have referred the patient has come for advice on account of defect of Form-vision, and has seldom said anything about Colour-vision. One of the first complaints made is often of a mistiness that prevents the patient from recognising the features of a person at a distance (the scotoma when small covering the person's face at a distance), and at the same time of difficulty in reading, which is not removed by spectacles. Occasionally they will say that people's faces look unnaturally pale. I have known two cases in which sportsmen found out the defect whilst very slight by their bad shooting: they could see the birds rise (eccentric vision) but just when they aimed the bird "was lost."

Question—When you have had a man who could not see red, and have shown him a red object, say a bit of sealing wax, what does it look like to him?—In accordance with what has been already said this will depend largely upon (1) the size and (2) the brightness (saturation) of the test object. If it be three or four inches long, and an inch or so wide, he will (unless very bad) usually recognise the colour, either because some part of its

retinal image falls on the undamaged part of the red-perceiving field, or because, though the image falls on none but damaged percipient elements, it occupies so many of them that a correct sensation is the result. But if the red test be of from 5 to 20 mm. diameter, the patient will call it variously "no colour," or "brown," or "black," or later on, perhaps, "white;" finally, after having recognised it correctly in the eccentric parts of the field, he may continue to recognise it correctly, though as a "paler" a "duller" red, even at the centre. If a light-green spot be used as the test, it will commonly be called "white," sometimes "grey," on the defective area. I think they never call pure red yellow; certainly not often. They more often call it brown.

Question—With reference to tobacco amblyopia, is there any particular kind of tobacco you have found to cause it more than others?—All strong tobaccos, especially "shag," cavendish, and strong cigars.

Question—Are cases sometimes caused by alcohol, or by tobacco only?—There is a great difference of opinion as to whether alcohol alone can produce this form of amblyopia, or any form at all commonly. Some think it often causes central amblyopia, though I have never seen a case where alcohol alone had done so. There is abundant evidence that tobacco alone can cause it in cases of teetotalers. We also know tobacco cases occur in women smokers. A large number of carefully recorded facts by various observers, bearing on the influence of alcohol and many other points in relation to this so-called "toxic" amblyopia will be found in the "Transactions of the Ophthalmological Society of the United Kingdom," vol. vii, p. 36 (1887).

Question—In cases of persons who are heavy smokers of strong tobacco who get amblyopia, is it not usually some mental depression such as would be caused by the loss of a wife or child that causes the tobacco to take effect?—Yes; I have for many years insisted strongly on the frequency with which the onset of failure of sight in smokers has been preceded by something which, directly or indirectly, has caused a lowering of general vigour. It is comparatively seldom that when tobacco amblyopia comes on the subject is in his usual vigour and health.

Question—Do you think these cases of scotoma in railway servants and others are not common enough to be worth consideration?—They are not at all so rare as to be unimportant from the point of view of signal reading, but the safeguard is that they always suffer from defects of form-sense, and that causes them so much inconvenience that they take advice for it. Though they might now and then manage to carry on their signalling duties for a time, such an event would be rare.

Question—Do you find that people engaged in the open air suffer less in this respect than those employed indoors, such as clerks?—I do not know that it affects any class particularly, apart from depressing or exhausting causes.

Question—You think it would be advisable after a railway accident to test the driver and guard for central amblyopia?—Yes; I think it would be well to do so some little time after the accident, since shock is one of the causes of the lowered vigour which so often precedes this failure of sight. I had the following case in point:—A railway servant jumped off the foot-board of a train moving at about 10 miles an hour. He was badly shaken, and his general symptoms were for a time suspected to indicate grave degeneration of the brain and spinal cord. His sight also failed, and this was also thought to point in the same direction, until it was found, on careful examination, that he had the scotoma of tobacco amblyopia, and that he smoked. His sight returned perfectly when he left off smoking; he also gradually recovered from the symptoms of shock.

Question—Your opinion is that, contrary to the ordinary so-called colour-blind persons, these people with central scotoma have a sufficient defect of form-sense to warn them?—It is always great enough to be a safeguard. It is the same with other diseases of the optic nerve, but the clinical features of cases of atrophy of the optic nerve, from whatever cause, are, generally speaking, less uniform than those of the axial neuritis that occurs commonly from tobacco smoking, and perhaps occasionally from other toxic influences, and as a substantive disease. The *axial neuritis group* presents tolerably uniform symptoms, because only certain bundles of fibres of the optic nerve are diseased, viz., those which supply the central area of the retina, the disease very seldom spreading to the other bundles. The symptoms in other forms of optic nerve disease are less constant, because the malady does not show any such constant selective affinity for certain strands of fibres, but may affect some or all, and with various degrees of severity and of permanence, according to the seat and nature of the originating cause. In one very important group of cases, the group known generally as “progressive atrophy” of the optic nerve, it is the rule to find that the field of vision in the earlier stages is curtailed at its circumference, either all round (“concentric contraction”), or more commonly by the loss of sector-shaped pieces. Together with such *total* loss of portions of the field there is usually a lowering of sensibility over the area that remains, so that “acuteness of vision” is damaged also; but sometimes the centre remains very good in spite of great loss of peripheral vision. This “progressive atrophy” is most commonly a part of a similar disease affecting the spinal cord (and sometimes the brain) in the form of tabes dorsalis or locomotor ataxy. Marked colour-blindness is the rule in progressive optic atrophy, but, according to my own rather rough clinical notes, the loss of colour perception does not stand in a perfectly uniform relation with loss of (central) acuteness or with loss of field;*

* I have not collected any observations on this point since publishing such as I then had, in 1883, in vol. iii of the “Trans. of Ophth. Society,” p. 256.

nevertheless, in by far the majority of cases of this sort, as in central amblyopia from tobacco, &c., acuteness of vision is so much lowered as to be for the patient the most important symptom. I remember only one case in which the patient, a sailor, who had been accustomed to steer and to look out, discovered his inability to distinguish the colour of ships' lights, whilst his acuteness of sight still remained good enough for ordinary purposes about the ship. (Wm. B. “T.O.P.,” iii, 33.) How the loss of colour-vision stands in relation to loss of light perception in cases of optic nerve disease, I cannot say. People suffering from disease of the optic nerves often come saying they want glasses for failing sight, and naturally think the defect can be remedied by glasses. Glasses do not help the matter, though they of course may remedy the form so far as the defect is due to the images not being properly focussed.

Question—It has been alleged on behalf of railway workers that the sense of colour-vision becomes impaired after long hours of work and want of rest?—I have no evidence on that subject; but I should not have thought it likely to be true.

Question—Have you had any experience of hysterical colour-blindness?—Yes, but I have not put together my facts about it. Contraction of field and lowering of acuteness of form-perception are nearly constant; but the state of colour-perception, according to my experience, varies greatly. The fields sometimes show spiral contractions, but not always. The spiral contraction is, as a rule, put down to exhaustion.

About congenital colour-blindness I have not much to say, except that it is common in men and very rare in women. I have one splendid case of a colour-blind woman—the only one I have ever seen of the kind. It is not common green-blindness; I think it must be blue-blindness. She never makes mistakes about green, and is always wrong about other colours. I use Holmgren's test.

Question—You have had some experience with the use of a lamp? Can you make any statement about that?—The results with the lamp vary very much. I cannot quote statistics; but I think it is true that as a rule people congenitally colour-blind will make fewer mistakes with such a test than those whose colour-defect has come on with disease of the optic nerve, e.g., tobacco cases. But both classes are liable to make mistakes if taken off their guard by varying the colour of the glass, the size of the aperture, or the brightness of illumination. A further cause of variation lies in the interest or attention that the examinee shows; he may make mistakes at first, but learn to correct them if the tests are repeated. I should not myself, as at present advised, rely upon a lantern-test alone, either as a scientific test of colour defect, or as a trustworthy guide for the detection of those whose colour-defect is dangerous. The wool-test is much less open to these objections, because the number of tints and shades is so much larger, and possibly

also for some optical reasons. In my testing lantern I have a diaphragm with holes of different sizes, representing the regular railway lights at different distances, with red and green glass supplied by one of the Companies, and in addition a number of bits of smoked glass. I often, but not always, succeeded in getting the persons tested to confuse red and green, and also white smoked light with coloured lights. The persons tested should stand at a distance of 12 feet, and I vary the size of the hole so as to represent a railway signal at different distances. Some time ago my colleague, Mr. Lawford, examined an engine driver from the South Western Railway, who came to St. Thomas's Hospital because he had been rejected that morning on account of colour-blindness, although he had been two years previously tested and passed. His eyes were perfect but colour-blind. With Holmgren's first series he matched green and red; and with the next series he confused greens and greys. He was tried with the lamp, and then confused red and green in both large and small dots, making more mistakes with green than with red glass. Such a man, if he were very much on the watch, might go on for many years with safety. He said he never experienced any difficulty in telling the colours of the signals because the red "glistened." I had a somewhat similar case with a medical student who had been at sea. In trying him with one of Stilling's tests, consisting of coloured letters on a black ground, I found he could not see green on black. I asked him if he could tell lights at sea, and he said, "Yes, quite easily; there is the red light and the black light." I lately saw a man who had been a stoker on the Great Eastern Railway for a number of years and now wanted to pass as a driver; but on being tested was rejected as colour-blind. He did not believe himself to be so, and came to Moorfields Hospital for a certificate that his colour-vision was perfect. He proved, however, to be an ordinary red-green blind. On the other hand, we have had men appealing to us there because they had been rejected who really saw colours quite well.

Question—That probably occurred through using the naming tests?—Yes, I suppose so.

Question—Does night-blindness throw any light on the question of colour vision?—I do not think so. Patients who have night-blindness are certainly not colour-blind. In such cases I think all colours disappear equally, together with form, but I cannot speak with any authority on this point. A very night-blind person would be deficient in the day also. Temporary night-blindness is due to some want of nutrition of the retina, and is often associated with scurvy. It is now a rare disease in this country. The ordinary varieties of night-blindness are due to disease of the retina.

Question—Does this failure (the permanent night-blindness due to disease) come on in middle life?—It varies; some are born with the disease which causes it, and with others the disease

comes on later. In most cases it gets worse. It is not due to the pupil not dilating, though a fixed small pupil does cause a slight degree of the symptom.

There is a group of cases of colour-blindness always associated with defective acuteness of vision, the peculiarity of which is that the affected persons see best by dull light, and cannot see nearly so well in bright light—"day-blindness with colour-blindness." The condition is due to disease occurring very early in life, and is stationary. It generally affects several members of a family, and the females as much as the males. Usually the colour-blindness is complete, and often total. Probably some of these cases have from time to time been taken for examples of ordinary congenital colour-blindness.

Evidence of Captain MACNAB, of the Local Marine Board at Liverpool.

I am Chief Examiner and Secretary to the Local Marine Board at Liverpool, established under the Merchant Shipping Act. I supervise the colour-testing, and frequently conduct it myself; in fact, I examine more than anyone else. We have a dark room in which we take the candidates, and have the usual lanterns supplied by the Board of Trade, with the uniform slides. We place the man 18 ft. away from the light, and ask him the usual questions. We also ask him to name colours; if he succeeds in passing all these tests we give him a certificate, and, if not, we reject him.

Question.—What are the usual questions?—We use the usual shades, and ask the man to name them. They are the same colours as the Board of Trade use. Both officers and men are examined by me. They are examined on first entering, and afterwards. The officers generally come from schools, and are of the apprentice class; we also get a great number of men from large steamships—common sailors.

Question.—Are either the officers or men allowed to enter the service of the Companies without passing the prescribed examination for colour-vision?—Yes, anybody can go to sea without passing the colour examination. The last come because large steamships find it wise to have them tested. They come direct from the ships. As a general rule, some official from the docks, who has to look after the gathering of the crews, comes and brings a batch of men—quartermasters and sailors—with him. A quartermaster is simply a man who steers, and keeps the gangway. He wears the Company's uniform. He would often have to take the look-out duty. On an emergency, say, if a large number of the crew were down with fever or dysentery, they might take a lower class of men, who had not been examined for steering and look-out duty. When I was at sea it was customary to take "look-outs" from anywhere. The examination for colour-blindness had not then been instituted. It is usual now to submit men to be tested

for colour-vision in the best Companies, such as the White Star, Cunard, Guion, National, and Inman—all the large Atlantic Companies. They get no higher pay on account of having a certificate. They would not be admitted in the large Companies if rejected by me. Every officer who applies for a certificate of the coasting Companies is tested in colours. There are two different ways of applying to be examined; one, when a man applies to become an officer, and another, by which any one can come, without formality, by paying 1s. to be tested, and, if passed, certificated on the spot. If a man fails, he can come up again. We had one who came up four times. I have had cases where they have failed once, and afterwards succeeded, but this happens very seldom. I have seen a fair number of failures. From May 1, 1877, until December 31, 1889, in my own port, 12,272 persons were examined for certificates as officers; 90 failed, which gives 1 in 136, or .73 per cent. for that class. I cannot tell in what proportion those men who had already passed were to those examined for the first time. In the figures I gave the same man is not counted twice; they are individuals, and I can say, speaking from memory, that I do not believe there were two people who had been failed at other ports and passed at ours. Prior to 1885 there was great diversity in the mode of conducting the examination, the appliances being different; Liverpool, before that date, was, I believe, the only port that had a dark chamber and a decent lamp; after that, the Board of Trade issued uniform lamps and glasses. With reference to the failures, there is another class showing a higher percentage than the officers, viz., those paying the shilling fee, principally quartermasters and fore-castle hands. Since May, 1880, when the 1s. fee system began, we have examined 942; out of these, 34 failed. During the four years 1887-1890, when the records were kept more accurately, 22 out of 777 failed—a percentage of 2.83. Most of the applicants were rough seamen, with some few of the officer class who had failed before.

Question—Have you any explanation to give why a man succeeds after once failing?—Perhaps by getting the colours and being coached up. His colour sense might be improved, but I think not.

Question—Do you find many people ignorant of the names of colours?—That is one of the great difficulties I have never tried to solve; it is a scientific question. I have never tried with two lights at the same time, and asked the candidate to name them. I always conduct the examination exactly in accordance with the Board of Trade instructions. Men do appeal from my decision and go to an oculist; in fact, if ever I do fail a man, and he is young and possibly curable, I advise him to go to an oculist in order to ascertain whether he is colour *blind* and *incurable*, or colour *ignorant* and *curable*. I sometimes find in testing a man coming up for a higher certificate, that he fails the second time, although he has once passed. I do not trace this to any

peculiarity of vision, but I believe, in most cases, the first passing was a fluke.

Question—I suppose that if it is possible to pass by a fluke, the method of examination is not satisfactory?—I am not prepared to say that I think the colour test, as conducted at present, is unsatisfactory, if properly applied. If I have any doubt I always make a man repeat the names of the colours in his own language.

Question—I think you said something about crammers. If they cannot develop colour sense, how do they help the candidates? Is it by showing them the lamps, or using the apparatus?—I believe they provide themselves with a set of colours as nearly like ours as possible, or the same. I know one case of a teacher with a similar set. He would show a colour to the man who would say, perhaps, "it is red," and tell him that whenever he saw that which appeared to him to be "red" he was to call it "green." I am not quite satisfied as to the proper names to be given to all the coloured glasses we use. There are some you might perhaps be in doubt about if you had not been told the names. These are the confusion tints.

Question—Do you think there is anything beyond colour, any kind of perception, which would enable a man to distinguish colour?—No, I think not. I sometimes use the wool test, which consists of different coloured wools with a number attached to each. I give him a test skein, and tell him "to toss over all of this sort of colour." I apply this test to perhaps three cases in a year. I think the ignorance in naming colours is getting less. I believe many of the first failures were recorded because a man did not know the names of colours. I think it of supreme importance in our business to ask candidates the names of colours, and it is better than asking them to match colours, because the man must transmit the name of the light he sees to the officer of the watch, and if he gives the wrong name it might mean disaster.

Question—Your impression is that colour *knowledge* is as practically important as colour *vision*?—Precisely; only that the one can be acquired, but not the other. Something ought to be done as to vision; we have no authority to test for that.

Question—Do you take a man with weak eyes?—We cannot stop such a man going to sea, though he would not see in a heavy wind or rain.

Question—Do you think fog interferes with the lights?—Certainly; it takes from the carrying power, and turns a green light to white.

Question—Have you any means of explaining as to this to men joining the service?—No, it is not within our scope.

Question—Could you make any suggestion as to what should be used as a test for acuteness of vision and power of seeing at a distance?—Not beyond standing by the man, and ascertaining how he can see things at a distance. It would not be sufficient

for him to pass such a test once; he should be re-tested every ten years at least. Not many men come to me wearing glasses. They consider it rather *infra dig.*, and glasses would interfere with the discharge of their duty, being affected by rain, &c.

Question—What is your opinion on the practical importance of the question of colour-sight in the Navy and Mercantile Marine, and as to any facts which have come under your notice, that tend to show it is an occasional cause of disaster?—I have no statistics or cases on record, but it seems to go without saying that, if a man cannot describe colours, it may lead to disaster, and there may have been many disasters that could be traced altogether to it, although we cannot prove it. The importance of the question cannot be over-estimated. I know of no instances of collision or shipwreck where the colour-vision of the persons possibly in fault has been tested in legal or other enquiries, but I know an instance of a man who was chief officer of a steamship and had been in the Company many years, and was promoted to the command of a large vessel, and then asked to get his certificate for colours. He tried at London and Liverpool and failed at both, and then realized the fact that he was hopelessly colour-blind. If the Company had not asked as to his colour-vision he would probably be at sea at the present time. That man had passed the Board of Trade examination in navigation and seamanship, but not for colour-vision. Another man I know of, who has failed in colours six or seven times, I have seen in command of a vessel with the Board of Trade highest certificate as an extra master, but he is unable to distinguish colours. He passed his examination for navigation, but his certificate is endorsed "colour-blind." The Board of Trade cannot forbid the employment of such a man. It is very unsatisfactory that a man who has failed to pass the colour test should command a vessel, and I should recommend legislation to alter this, as that is the only way it can be stopped. I think that beyond being able to distinguish red and green lights when they are together, a man should know the green, even if he could not see the red light, and many of these colour-blind people would be able to distinguish between red and green if they saw both together, especially if crammed up beforehand. The diminution of the inability to recognise green becomes of great importance. There are only two roads to go, and you must be either right or wrong. I sometimes find candidates call our green light white.

Question—Supposing they could distinguish on board ship a green light, by its appearing to them white, and the other red, would that be sufficient?—No, because they might mistake a steamer for a fishing boat. It is essential to be able to distinguish green as accurately as possible, and at as great a distance as possible, and if this power is diminished to a certain extent, danger may be apprehended.

Question—There is often no time for deliberation in forming a judgment?—No. Often the light cannot be seen until the vessel is

close, and one false move precipitates calamity. Stormy weather is at times the clearest, but often the condition of weather is such that a man, upon seeing the lights, is close upon the other vessel, and has very little time to make up his mind. That is, in fact, the normal condition of affairs round the British and American coasts. The man who can see green thoroughly and easily will have a larger margin for action. In the case of a man whose vision is imperfect, he would waste his time in making up his mind as to the colour, and pride would not allow him to call anybody to his aid.

Question—You have had large experience at sea?—Yes.

Question—Do you think red and green are the best lights?—The best up to the present, but we want a better green; it is too weak. It is apt to turn white in a fog. It does occasionally happen in enquiries that there is a difference in the evidence about the light shown, but I cannot answer from my own experience. I have never given evidence before the Admiralty Court.

Question—Would you recommend, in cases of collision, that an examination should be made as to the colour-vision of the officer in charge of the vessel?—Yes, whenever there was reason to doubt about it.

Question—Have you any knowledge of training ships?—I examine boys from the "Conway" and "Indefatigable," as officers, in one case, and sailors in the other. The examinations are systematic. If I reject them, it is a check against their further going to sea. Sometimes a boy does not want to go to sea after putting his parents to trouble and expense, and finds colour-blindness a good way to get out of it. I had one case in which a boy called every colour by its wrong name, avoiding the right name all round. I failed him, and told his people I did not think his colour-blindness was genuine.

Question—Then after receiving all the advantages of the training he might be rejected?—Yes, and he might be made a junior officer before he appears for the examination, and perhaps be in charge of the ship in fine weather. The authorities are very careful with regard to colour-vision, and reject a good many. I examine 40 to 60 of the "Conway" lads in a year.

Question—With regard to the "Indefatigable," supposing a boy was found to be colour-blind, would the authorities of the ship dismiss him?—No; he would be quite free to complete his education.

Question—Are you quite satisfied with the tests you use?—I believe they answer the purpose, though they will not tell whether a man is colour-blind or colour-ignorant. I think there is a very bad chance, practically, of a man passing the test who is colour-blind.

Evidence of Staff-Surgeon PRESTON, R.N.

I have had three years' experience with the testing for Colour-vision in the Navy, that is, the examination of recruits for the Marines, domestics, stokers, and boys; also of every class of officer entering the Service, at the Admiralty. In 1888, for which year I only examined a proportion of the cases, the total number examined was 2,935, in 1889 3,856, and in 1890 3,961. With regard to the Service, it is a matter of great importance that we should not have any persons either with defective vision or imperfect perception of colours, and with a view to that end a printed form is always forwarded to the parents or guardians of any young gentlemen coming up for naval cadetships, or assistant clerkships, recommending that previously to their educational examination for these posts by the Civil Service Commissioners, they should be medically examined by their own private practitioner, and special stress is laid upon the fact that the candidate would be unfit for the Service if affected with blindness, or defective vision, or imperfect perception of colours. [The Witness here handed in a copy of the form referred to, calling special attention to paragraph 4.] The larger number of those entering the Service, principally blue-jackets, stokers, and Marines, have nothing of that sort submitted to them, but they are subjected to a preliminary examination by a couple of Sergeants, before being passed on to me as medical examiner. The preliminary, or rough test, consists of the ordinary asking of questions as to bright colours on card-board. I may remark that I see about 3,000 men and boys a year at the *Rendezvous*, but there are nearly three times that number who come in the building applying to enter the Service, or raised by the Recruiting Sergeants; only one-third, however, come to me, the rest being rejected for some cause or other. With regard to the men—stokers, Marines, servants, and dockyard apprentices—I simply use the ordinary colour test. [Test board handed in.] Each person in succession has to cover one eye, and then a colour is pointed out, and he is asked what colour it is. If there is the slightest hesitation in replying, Holmgren's wools are used. That is the system which has been used for many years with men and boys, and I have found, as a rule, defective colour perception is hardly to be found among that class of people, doubtful cases being in nearly every instance due to colour ignorance, and appears to be confined to men and boys raised in the country recruiting centres of England and Scotland. In many instances these persons will confuse the brighter colours, yellows and blues; they understand green, but frequently, especially with boys raised in the Eastern Counties, where they are recruited from agricultural labourers, they cannot detect some of the test greens, although they will at once recognise grass-green with Holmgren's wools. I am speaking of boys from the country as contrasted with those raised in London or twenty miles round, of whom a large number come to us every day.

In the ordinary examination the candidate would be told to point out all the colours on the board. We find it necessary to state to the candidates that there are four simple colours—no crimsons, oranges, or violets.

In case a candidate fails to name correctly the colours on the board, we satisfy ourselves further by using the wool test. The men who are going to be examined have no access whatever to the test board, and to vary the positions of the colours we turn the board round. We carry our tests much farther in the case of officers, particularly naval cadets and engineer students, who are required to have absolute normal vision and colour vision, each being examined separately by Snellen's test, supplemented by flags and wools. They stand at a distance of 16 feet, and are shown each of the flags separately, and have to name them in quick succession, tested with either eye. That is the first test, and the next is Mr. St. Clair Buxton's marine telechrome. [The Witness exhibited this apparatus, and explained its use.] The glasses in this lantern are used at the same distance as the flags (16 feet), with red, blue, violet, green, and white lights in quick succession, and with the fogging apparatus, which is simply a piece of glass fogged on one side, with no lens whatever. Supposing a candidate mistakes between red and green, we take a further test. The candidate is allowed to wait while the rest of the examination is proceeded with, and is then re-examined on the doubtful point, as it is absolutely necessary that an executive officer should discern at once every coloured flag, either of our own or foreign nations. In several cases the Medical Director-General has allowed a young gentleman to come up a second time for examination one or two days later, but I have looked through the records and find they are never successful when once defective colour perception has been detected.

The figures giving the proportion of candidates rejected are as follows:—In 1888 there were 214 examined for Naval Cadetships, and of those, one was rejected for inability to distinguish greens from browns, and another was found ignorant of the names of colours. It appears, however, in the records that upon being examined subsequently the same day he was passed. In 1889, out of 293 examined, there were 1·02 rejections for defective colour perception. Of these one was rejected for confusing greens and browns; one was absolutely colour-blind; and one in the immediate perception of colours was uncertain. In 1890, 305 naval cadets were examined, the percentage of rejections being 1·31. Of these one was rejected for inability to distinguish between greens, reds, and browns; and three were rejected for being unable to distinguish green from red. These were boys whose parents had received the warning as to defective sight; but, as a rule, parents do not care to go to the expense or trouble of a medical examination beforehand by their own doctor.

Although I have laid great stress upon promptness in replying to the questions in examination, we do not reject candidates for

want of promptness. If there is the slightest doubt we re-examine, always testing such cases with Holmgren's wools before finally rejecting them. Naval cadets and engineer students have four examinations in colour-perception before they are declared unfit.

The conclusion in the case I referred to as totally colour-blind must have been arrived at in the ordinary way by Holmgren's wools, the flags and buntings. I may mention that if boys, when sent to the training-ships from our *Rendezvous*, are suspected with regard to their colour-perception, it is reported, and they are, when on the ship, tested by night as well as day: by day with the telescope up to, say, the distance of a mile, and at night-time with the coloured lights at the full length of the ship. [The Witness here exhibited a specimen of the Admiralty green glass, as used in the lights, and explained with reference to it.]

We never find anybody who can distinguish the Admiralty green who cannot distinguish a greener green. Where candidates persistently confuse red and green in the lantern, but sort the wools correctly in using Holmgren's test, it is the fault of the lantern not being sufficiently green. Speaking of colour-blindness which is not congenital, I should say that all the naval cadets to which I have referred were, as far as our registers show, rejected for colour-blindness which was congenital, but I should have difficulty in getting further information upon that point.

We have no records of men with normal vision among whom colour-blindness has been brought on by disease.

Naval officers are never examined after their appointment, and, therefore, they might be suffering from tobacco amblyopia; but naval cadets and engineer students are not allowed to smoke until they are eighteen years of age, and on the *Britannia* they are, of course, constantly being examined with colours.

When they have once been passed into the Service they would not be examined again systematically; but if there was any suspicion as to colour perception, they would be examined by the medical officer of their own ships, and invalided, and if found to have defective colour-vision, be removed from the Service.

There have been a few cases of blue-jackets who, upon offering themselves for rating as signalmen, were rejected as colour-blind, but upon closer examination it has been found to be due to defects of the accommodation of the eye.

This would be brought out in the following way:—Upon a man being examined for signalman he would be required to read hoists of 20 or 30 flags at once, and upon being asked by his examiner what a flag was would answer "w" instead of "q," and upon reference it would be found he mistook red for green. This might be due to defective vision rather than defective colour perception, but this would come out in examination at the shorter ranges.

All men are examined, as every man is a look-out man more or less. All pass a course of musketry and gunnery instruction,

and before this are medically examined to test their power of vision, because if this were not absolutely normal the training would be time thrown away.

They are examined by the officers of their own ships by the method laid down in the Queen's Regulations: coloured flags supplemented by Holmgren's wools.

I do not know of any case of an officer becoming colour-blind through disease. The defects that are found are generally those of accommodation, and occur primarily with officers about 45 years of age who are presbyopic.

To the best of my belief, there is no officer in the Service at the present moment at all defective in colour-vision; that, I believe, is so with regard to the executive branch, and engineers who are in charge of the machinery of torpedo boats. I do not think that there are any Marine or medical officers defective in colour-vision.

I know of no cases of collision, where there has been a court-martial on the loss of a ship, in which any doubt has arisen as to whether it occurred through inability to read the signals, except that of the *Iron Duke* and the *Vanguard*, where the look-out man was said to have been myopic. In such a case the question would undoubtedly be thoroughly gone into, because it would be the sole defence of the man.

The look-out men are put through the card test as boys, and are for five years after undergoing a constant test by their instructors, with flags and bunting, from a few yards to a mile, and with the telescope as well.

If a man was wrong in his signals, he would be detected, and examined by the medical officer, and then sent to hospital for further observation.

With reference to the statistics as to recruits in the Marines, I have looked back for six or seven years, and find none rejected as far as the Medical Officer was concerned, but they have been previously sifted by the Staff-sergeants, who examine for colour- and form-perception, using Holmgren's decided colours. I only see one-third of those who come up, the Staff-sergeants having probably rejected the rest.

No recruits who have passed the wool test are found to be inefficient subsequently among Marines, domestics, and artificers: but a small percentage, and with boys but an infinitesimal number, failed subsequently. It often happens that a boy who passes our test in London, and finding a life on board ship perfectly new to him, gets discontented, is told by somebody that by saying he does not know what certain colours are he may be sent to hospital, and invalided out of the Service; but they are examined at the hospital, and in all cases returned to their vessels.

Evidence of Dr. GEORGE LINDSAY JOHNSON.

The CHAIRMAN: You are aware, perhaps, Dr. Johnson, that this Committee is investigating the general subject of colour-blindness. We gather that you have given your attention to the subject, and should be glad of any information you can give the Committee as to your experience of practical testing by various methods?—I am acquainted with most methods. I have used the spectroscope, and recently a simple form of Captain Abney's method. I have also had a little experience with Donders' method. Some of my testing has been with the spectroscope with a graduated circle, in which you read off the point where the spectrum appears to the patient to end. It is only with red-blind and green-blind cases I have had much practical acquaintance; although I have had one violet-blind. In using the spectroscope, I ask the patient to fix the point where the spectrum appears to end, and read it off on the scale, to see if I can get an improvement benefiting the patients who are red-blind, and in order to practically measure the improvement under special treatment. I may say with coloured wools or ordinary reflected colours I do not think it is so easy to ascertain whether patients make a definite improvement as by measuring with a Vernier's scale, with which the exact limit to which the red end extends can be made out.

Some patients find a difficulty in fixing the exact limit to which the red extends; but, as a rule, with intelligent patients, they can fix it pretty definitely.

The source of light I have hitherto employed has been a candle at Moorfields Hospital, and a paraffin lamp at home.

I find there is a variation according to the light used, and to prevent error on this account I have always used with the same patient the same source of light. Sky-light gives different results to candle-light, and also with regard to the fields of vision.

In taking fields of vision I generally use Dr. Priestley Smith's perimeter, which I have modified somewhat myself. I am not quite satisfied with the dead or pigment colours, but adapt to the perimeter an instrument for taking fields of vision, which I have had constructed for use with a 2-candle power incandescent electric-light.

[The Witness handed in a diagram illustrating the apparatus referred to, and explained with reference to its use.]

Question.—Does your experience go to prove that the spectrum colours all disappear at the same angle as Landholt holds, or do you find a difference in the disappearance according to the intensity of the light employed?—Yes. I am certain the difference is in accordance with the intensity of the light. I have not got figures at present with regard to the exact point where the colours stop with the spectrum, and do not think my figures would be of much use, unless interpreted by Fraunhofer's lines.

With regard to results obtained in increasing the sensibility of the eye to red in red colour-blind cases I have had a patient who came to me originally at Moorfields, who had been rejected by the Board of Trade because he could not see bluish-green or red lights on board ship. He was extremely colour-blind with regard to red, the red colour being shortened nearly up to the orange, so it occurred to me that acting on the supposition that in his case the trouble was probably central and not peripheral—for I could find no change whatever in the disc—I got him a pair of goggles so as to completely exclude all daylight except what filtered through the best red photographic glass with which they were fitted. I told him to wear these goggles the whole day long until he went to bed at night, not taking them off until the lights were out. He followed my instructions, and I tested him every consecutive month with Holmgren's wools, and noted on a list the colours in which he made mistakes. At the end of a month I found a considerable improvement, and at the end of three months his colour-vision was nearly perfect, being wrong in only three out of forty, whereas at first he was wrong in thirty out of forty. I sent him again to the Board of Trade for re-examination, and they found he was so much better than before that they told him still more, he might come to them again and they would grant his certificate. He went up again and passed completely in the red and green glass test with the lantern, but failed on the card test in the light pink and light blue. The last time I heard he had got the post of mate of a vessel trading between London and the Netherlands.

He wore these coloured glasses up to the time he passed. He said it was a great trouble seeing everything red, but insisted on keeping to them, notwithstanding the inconvenience; and upon testing him with the spectroscope—which is the only absolute test we possess—there certainly was an improvement in his vision as far as the extent of light towards the red end was concerned. I asked him to define red, but from what I could gather he had always had congenital colour-blindness, and it was very difficult to say whether his sensation of red was the same as ours. It is my firm conviction that the continual stimulation of some part of the conducting fibres or sensorium—whether peripheral or central—of red, awoke a faculty of perceiving something which may be called red. I did not try whether his colour-blindness was central, nor whether he relapsed after leaving off his glasses, but will make enquiries.

I tried with two other similar cases, which got a little better, but afterwards they gave up the goggles, saying they could not see well enough to go about with the glasses. I do not think the case I have mentioned was due to tobacco, as the man hardly ever smoked, and his vision was very acute, being $\frac{5}{8}$ ths. or one line below normal, in either eye.

With regard to detecting colour-blindness by the ophthalmoscope I may say that I have strong reasons for believing there

are two forms of colour-blindness, viz., central or cerebral; and peripheral, or connected with the optic nerve, as in retro-bulbar neuritis, or in the retina itself, or the choroid. In those cases in which colour-blindness is congenital I can detect absolutely nothing with the ophthalmoscope which would lead me to suppose that the patient was colour-blind. I can, on the other hand, exhibit a number of diagrams showing marked changes in pathological colour-blind cases. The portion of the disc affected is more extended, and there is that wedge-shaped triangle on the outer side of the disc which is so characteristic of tobacco and other narcotic amblyopias, only in these cases it is generally more extended.

[The Witness here handed in a number of charts illustrating cases of colour-blindness, and called special attention to a pale spot on the retina which was characteristic of such cases.]

I have brought with me a patient who has perfect colour-vision with one eye, while in the other she has no colour whatever. She describes the appearance of the spectrum as being like a grey smear. I cannot find that she has any perception of violet.

Question—I think you said you had another point to bring before the Committee?—Yes. I have some information, the result of two or three years' study, which I am not sure exactly regards this Committee, but I have made some experiments showing that if you place glass in front of the eye so as to wholly exclude daylight as far as possible, and have glasses made so that only the blue-violet end of the spectrum passes through, cutting off orange and part of the yellow, the field of vision for white, if contracted, will after a week become enlarged to normal, and that holds good with some cases of detachment of the retina. I was induced to make a large number of experiments with rabbits to ascertain the reason. They were kept in a hutch-like photographic chamber so that no other light than that through the red or blue glass could reach their eyes. After a certain time they were killed and put in a black bag, their eyes being fixed in osmic or nitric acid. I found a distinct anatomical difference between the retinas of the animals under the different glasses; and these differences come under four heads:—

Firstly, in the animals kept in the blue light the rods of the retina adhere much more closely to the little processes of the hexagonal prism, so that the retina cannot be easily detached after death. Secondly, the pigment under blue glass is increased. Thirdly, the retinas take up fluid more easily than they do in the opposite colour; and lastly, not only do they stain much better in the staining fluids, but are also more developed, and seem to increase and multiply more than in the red glass. These four points hold good for all rabbits. It seems to me that animals kept under a constant source of blue wave-lengths have certain changes effected in the retina differing from those under the red end of the spectrum, and that possibly may account for the

reason that I find the field of vision increased in almost all cases of patients whose field of vision has been contracted beforehand, if kept for a length of time wearing the goggles I have referred to. I am not prepared to say whether if the rabbits are exposed to ordinary light the retinas would return to their former condition.

Question—It is said that photographers suffer from working constantly in a red light; do you think that is so?—No; but I think they suffer from bad ventilation, as a rule.

Question—You say that after death there is more difficulty in the detachment of retina after keeping the animals in a particular light; would that have any application to colour-blind cases, or point to any cure?—I cannot positively state an instance of a detached retina going back, but in almost all cases of slight detachment of the retina, where the field of vision has been cut off over a certain area, that area has been considerably increased after wearing blue glasses, except when separated by effusion and forms of umbrella detachment, when the retina becomes, as it were, bleached.

Question—Have you had any experience with progressive atrophy, as to whether persons suffering from it have a lack of colour-sensation?—I find their field of vision, both for white and for colours, is extremely contracted, and that nothing I have ever tried for them has done the slightest good. I have taken the field of vision for a great many atrophies, and find blue is the last colour to disappear, as well as the most extended. I have never found a patient with a blue field and no other, but I have found blue extends further than any other. According to Herring, the blue and yellow field ought to be co-terminous, but I do not find that to be the case.

Evidence of Dr. EDRIDGE GREEN.

The CHAIRMAN: I believe you have paid a good deal of attention to the question of colour-vision, and perhaps you will be so good as to describe to the Committee the methods you have used in your colour tests, and the general character of the results obtained?—[Witness handed in a diagram illustrative of psychophysical colour-perception, and explained as follows]:—

The theory is that the perception of colour is a perception of difference; colours are confused by the colour-blind, not because of any loss of substance, but because the individual cannot perceive any difference between the rays of light included in a portion of the spectrum which appears monochromatic to him. The size of the monochromatic band varies with the individual. A person who has very defective colour-perception has a monochromatic band so wide as to include several colours which are easily distinguished by a normal sighted person.

In some cases seven colours are seen, and then the seventh colour appears at the point where it should appear by theory. In the first degree of colour-blindness only five colours, or points of difference, are seen in the spectrum; in the next degree four; in the next, three; then two. Then a neutral band appears at the blue-green junction, and this increases in size in different cases until total colour-blindness is reached. Therefore, the vision of the normal-sighted being hexachromic, the vision of the colour-blind is pentachromic, tetrachromic, trichromic, or dichromic. It will be noticed that the greatest difference is to be found between the 3-unit and the 2-unit cases of colour-blindness, the primary colours for each being quite different. The two primary colours for the 2-unit are yellow and blue, and they each represent half of the spectrum. In the case of the 3-unit the three primary colours are red, green, and violet. Red combined with green forms yellow; violet combined with green forms blue; so it is evident that these colours occupy the positions which I theoretically allotted to them.

The above refers to the number of approximate psychophysical colour units. An approximate psychophysical colour unit is a portion of a physical series which contains physical units that are not easily distinguished from each other, and are so much alike as to be called by the same name. An absolute psychophysical colour unit is a portion of a physical series which contains physical units that cannot be distinguished from each other even under the most favourable circumstances. It will be seen that an approximate unit contains several absolute units, but in each case the similarity between them is greater than the dissimilarity; for instance, there are many hues of red, but the character of redness enables them to be classed together.

The other chief cause of colour-blindness is shortening of one or both ends of the spectrum. This is probably due to some retinal defect, as neither light nor colour are perceived at the shortened end. It is distinct and separate from diminished psychophysical perception, which is due to defective size of the colour-perceiving centre in the brain.

Question—How would you establish the six or any other number of colours with the person you were examining?—A person who sees six will at once say so. I test with a spectroscope provided with two shutters in the eye-piece, showing the examinee in the first instance red, orange, yellow, and yellow-green, because these are of nearly equal luminosity. I make him indicate the junctions of the colours; any colours can be cut off with the shutters, so that the person examined is not able from one colour to guess the others. I use an ordinary spectroscope (one prism), provided with shutters, as explained. The actual procedure in using this test is as follows:—I ascertain where the spectrum commences, where it terminates, what colours are seen, and where the junctions of the colours are, the

patient using the shutters until he is satisfied that he has obtained the correct junction.

Question—If you had say five points of difference, would they always come exactly in the same place?—Yes; such a case would not see orange as a definite colour.

Question—Would a patient recognise no orange, supposing a single colour was suitably chosen and distributed over a sensible field, and beginning from the sodium line?—A 5-unit case usually objects to the term orange; he would probably call it reddish-yellow.

I have not come across any 1-unit cases; that is the only one on the diagram that is not drawn from my own experience. I should explain that the diagrams are all drawn the same lengths, to demonstrate the psychophysical diminution of colour-perception and not the shortening of the spectrum, in which case another effect is produced, viz., the junctions of all colours are altered; a 2-unit, with shortening of the red end of the spectrum, puts the junction of his two colours nearer the blue than a 2-unit with an unshortened spectrum.

Diagram No. 6 shows a transition from red to violet; in such cases there is no neutral band in any part of the spectrum. The one colour passes into the other without any definite intermediate point.

In examining for scientific purposes the spectrum would be the first test, afterwards wools, pigments, or lights, in accordance with the spectrum examination.

Question—Would it not be easy to coach a person for this?—No, because he would never be able to hit off the exact junctions of the colours.

Question—Which class of the colour-blind would you consider as representing dangerous cases for signalling purposes?—I. Those who possess a psychophysical colour-perception with three or less units. II. Those who, whilst being able to perceive a greater number of units than three, have the red end of the spectrum shortened to a degree incompatible with their recognition of a red light at a distance of two miles. III. Those who are affected with central scotoma for red or green. The 3-unit would be unsafe, for though he would always recognise red and green, even to the lowest degree of luminosity, he would confuse yellows, especially dark yellows, with reds and greens, and generally call them reddish-greens; in fact, yellow has been described by such a patient as being of the same colour as a red clover field in full blossom. The 2-unit cases and below are absolutely dangerous. The 5-unit and 4-unit are safe.

[The Witness here handed in his Pocket Test, and explained its use, Captain Abney being asked to pick out all the shades of orange.]

Question—Would you describe a person as not having distinct orange perception, who could not mark out the definite regions on the spectrum bounded on one side by yellow and on the

other by red?—Yes; I should describe such a case as not seeing orange.

Question—I understand Dr. Brown's test comes out under your patronage; may we therefore take it that you approve of that method?—Not at all. A medical man might roughly test with it.

Question—Do you test by nomenclature or matching?—By nomenclature, combined with matching. Many normal sighted persons fail with Holmgren's test because they think a shade is a colour, paying as much attention to the one as the other; if you say "I want you to pick out all the greens," you give them something tangible to go upon. If a person in picking out twenty or thirty greens also picked out half-a-dozen reds, it would be certain he was colour-blind; but if he has to match a green wool he might pick out with the greens a light brown, and not be colour-blind at all, and the error could be rectified by explaining to him that the colour he selected was greenish-brown, reddish-brown, or yellow-brown, as the case might be. With Holmgren's test, under the same circumstances, he would have failed. This might be confirmed by asking him to classify the whole 150 colours.

Question—Do I understand you that a normal sighted person might pick out brown instead of pale green?—Yes, because he might pay more attention to shade than to colour. In testing practically I should first use the Classification Test. I should not begin with the spectrum with a practical test; it would not be convenient, and persons would object to it.

[At this point the witness was asked to apply the Classification Test to Mr. Rix. Mr. Rix was first requested to pick out all the shades of orange he could see, and in so doing he selected two skeins of wool of a decided light green. Dark blue and violet were matched as being of the same colour. In matching reds, a reddish-brown was picked out, but described as having more blue in it, and blue-green was sorted with the drabs, and referred to as being brighter.]

WITNESS.—The Classification Test is used in order that inexperienced examiners might not have to depend upon the Lantern Test—in which not more than twenty answers are required. I do not use the Board of Trade colours with that test, but my own. The person examined should be able to distinguish between the red, green, and white lights, either alone or modified with the neutral glasses.

Question—Why do you think it necessary to have a preliminary test to this?—In order that an inexperienced examiner may feel certain that the mistakes made with the Lantern Test are not due to colour ignorance.

Question—Have your investigations been with pathological or congenital colour-blind cases?—With both.

The principles upon which I examine are as follows:—The first principle which guided me in the selection of colours may be

illustrated in the following way:—Let us take an ordinary 2-unit colour-blind, and, having given him the set of wools belonging to the Classification Test, ask him to pick out all the reds. On examining the pile of wools selected as red, it will be found that the majority are red, but in addition there will be some browns, and yellow-greens. If he be then told to pick out the whole of the greens, the greater number of those selected will be greens, but there will be also greys, browns, and reds. In each case it will be seen that the majority of wools are of the desired colour.

If another 2-unit colour-blind be examined in the same way it will be found that, though he may not make exactly the same mistakes, he will in all probability pick out the same greens to put with the reds, and the same reds to put with the greens. The same result will be obtained if the colour-blind persons be asked to name a large number of colours. They will in most cases name the colour correctly. It will be noticed that the greens which were put with the reds when classifying the colours, will be called red in naming them. It is evident that the same idea has guided the colour-blind in each case.

This shows that, though a person may be red-green blind, he is not absolutely red-green blind in the sense of being totally unable to distinguish between the two colours. This is what we should expect, as the red and green are included in an approximate, not in an absolute psychophysical unit. The fact that they are actually judging by colour may be demonstrated by giving them coloured materials of different kinds, or by asking them to name a large number of coloured objects. To a person with a spectrum of normal length and no neutral band in the blue-green, it is necessary that the colours, to be considered as identical, must be included in an absolute psychophysical unit. One of the most definite signs that persons with a neutral band in the blue-green have a more defective colour-perception than the ordinary 2-unit, is that they will put together as identical a red and green which are distinguished by the ordinary 2-unit. In addition to this, they will mistake the reds and greens which have been confused by the ordinary 2-unit.

It will be seen that if we take a 2-unit and ask him to name a number of red and green wools, in the majority of instances he will name them correctly. But as, almost invariably, the same wools are chosen, for all practical purposes the same result would be obtained by asking a person to name a few of these wools. What more decided and brighter greens could we have than Nos. 76 and 94 of my Pocket Test? yet these are two of the greens which are called reds by the 2-unit. We should have accomplished as much by asking a colour-blind person to name Nos. 76 and 94 as if we had asked him to name a large number of greens. The colours in a test should, therefore, be those which the colour-blind are particularly liable to miscall. At the same time, their nature should be unmistakable to the normal sighted.

My second principle is that a colour-blind person will name

colours in accordance with his psychophysical colour-perception, and thus show distinctly to which class he belongs.

The third principle is that colours may be changed to colour-blind persons whilst leaving them unaltered to the normal sighted.

Fourthly, the phenomena of simultaneous contrast are much more marked with colour-blind than with normal sighted persons. Two colours not changed to the normal sighted, on being contrasted, apparently alter considerably to the colour-blind.

These tests are described in full in my book on Colour-blindness and Colour-perception in the International Scientific Series.

Question—How would you proceed, supposing you were asked by a railway company to test 500 men? What arrangements would you make, and how long a time would the examination be likely to occupy?—I should examine each separately, taking care that the others did not look on. I should first examine with the Classification Test, and then put them through the Lantern Test, taking twenty answers in each case. The process would only take about five minutes for each man, with even one examiner, because one man could be going on with the classification whilst another was being examined with the lantern. I allow ten minutes for each man, because I think that it is a great mistake to hurry, or be in any doubt about a case.

Question—At that rate it would require 80 or 90 hours to examine the 500 men?—It would mean a considerable expenditure of time. You want to know if a man can distinguish between red, green, and white at a distance of two miles. You might commit yourself to the Lantern Test alone; but if one man was sorting the wools while another was being tested with the lantern, it would take little or no longer to employ both tests, and in rejecting a man the double test would be conclusive. I regard both tests as desirable, and the Lantern Test as essential, for that would detect scotoma, whereas the Classification Test would not.

Question—You said you tried a progressive atrophy case, and that he was a 2-unit man, and his junction at about the E line?—I cannot say without referring to my note-book, but he saw one part of the spectrum as whitish and the other blue, only seeing those two colours. [Capt. Abney said:—When I tried him the junction of the white was at λ 4.733, between F and G, and nearer to F, there being a sudden commencement of blue at this point. At 26.5 of my scale he saw a little blue, and at 26.75 no colour.]

The essential part of my theory is that psychophysical perception is due to the brain and not to the retina. The theory I have formed is that the visual purple is liberated from the rods by light, and forms a photograph at the back of the retina, and that the cones only act as transferring organs of the percipient fibres, transferring the impression of the photograph to the brain.

Question—Is not that something like Kühne's theory?—No; he took a different view, the objection to which was that there are no rods in the yellow spot; but according to the theory I have advanced it would be essential that there should be no rods at the yellow spot.

Evidence of Capt. ANGOVE

The CHAIRMAN. You are, I believe, the Captain Superintendent of the Peninsular and Oriental Steam Navigation Company?—Yes, the Marine Superintendent.

You are probably aware that this Committee is investigating the question of colour-blindness, and the precautions taken by steam-shipping companies and railway companies against accident from this cause; we are therefore anxious to hear what is the practice of your company with regard to examining officers?—One of the Managing Directors and myself first examine applicants with regard to objects at different distances from the windows, then the Company's Medical Adviser examines them with coloured wools and for distance sight. They have to arrange and name the different colours. The vision for distance is tested by placing the candidate at the regulation distance from ophthalmic large test types, and the near vision by corresponding small type. It is required that both eyes should be equal to the average of good sight. We find, I am sorry to say, a great number who are not up to the standard, and often have to reject candidates in consequence.

Question—That is the procedure for candidates for the posts of officers?—Yes, but there is also a Board of Trade examination before coming to us which they have to pass in getting their certificates for various grades of officers.

Question—Do you take pupils in your Company?—No, not now; in former years we had two training ships, but they have been discontinued, so that every officer must now hold the Board of Trade certificate, which includes colour-vision. We often find candidates deficient, and reject a great number for defective sight.

Question—Then that points to the Board of Trade examination being unsatisfactory?—Yes, I do not think their examination is sufficiently rigid.

Question—Would you in your examinations reject candidates both for colour-vision and form?—Yes; and we give equal attention to weakness of sight with regard to seeing at long distances.

Question—Do you give rejected candidates a second opportunity?—No, but some go to an oculist's on their own account, and we get a special report from him. The weakness may be only of a temporary nature. I attribute a great number of cases to over-smoking with young men. We have traced several

instances to that cause, and where the smoking has been discontinued the sight has improved.

Question—You said, I think, that in deciding for colours candidates have to arrange coloured wools?—Yes, they have to arrange greens, reds, &c.; they are all mixed up, and the candidates have to pick them out, compare them, and sort those of the same colour. It is really the Holmgren test.

Question—After a candidate has been passed and admitted into the service, are there any tests subsequently applied?—Not unless he is reported by his commander. We have found some men colour-blind after being some years at sea and in possession of Board of Trade certificates. There was one instance of an officer who was found to be quite colour-blind, and was consequently transferred to a clerkship in the office. He had been passed by the Board of Trade, but not by us, as at that time we accepted Board of Trade certificates, and did not have our own examinations for sight. Since we have found these various cases, we have realized the necessity of having our own examination, and have called the notice of the Board of Trade to the fact. I have with me copies of correspondence which passed between Mr. Barnes and Sir Thos. Gray pointing out the fact to him that we have to reject so many young officers for defective sight. The Board of Trade admit the test should be more severe.

Question—Have you never heard of cases in which the failure of the eyesight of officers has led to accidents?—I cannot say that I have. The case of the gentleman I have mentioned who was colour-blind was discovered, I suppose, simply from his being on the bridge of the vessel with another commander. He rose to be a chief officer before it was discovered. His weakness might have led to accidents.

Question—Have you any statistics drawn up with regard to these cases?—Not beyond these facts that we are rejecting young officers. In a letter dated the 9th April, 1889, to Sir T. Gray, Mr. Barnes referred to the many painful interviews with candidates who have wasted six or seven years learning their profession with the expectation of entering our service, and who, when the height of their ambition is about to be realised, find we are compelled to reject them on account of defective vision. In one case a young fellow, with a new Board of Trade certificate, who seemed a desirable man, could not read letters 2 to 15 inches long 20 yards from the window. In the last two years a considerable percentage of the candidates passed by us, as in other respects satisfactory, have failed in the sight test for colour or distance vision; mostly the latter.

Question—Do you find any improvement in the Board of Trade examinations since you have written to them upon the subject of colour-vision?—I think they are getting more particular, from what I can learn from young officers.

Question—Another branch of our enquiry is as to what precautions are taken as to the vision of seamen?—We accept

the Board of Trade certificate which they have to obtain. Without that we do not admit them. We have no test for Lascars. Some of our ships are manned by them; but the look-out men are always Europeans.

Question—That leads to the question of what are the responsibilities of look-out men?—It is a very important position, as they have to report everything seen by them to the officer in charge of the bridge; though often he sees objects before the look-out man, because he is in a higher position. It would be a bad thing if a look-out man was colour-blind.

Question—Does he only have to report "light ahead"?—Yes, or on one bow or the other; but he usually gives the signal with a gong, striking once if the light is right ahead, twice if it is on the port bow, and three times if on the starboard bow. He would very likely sing out, "green light," or whatever it might be, after striking the gong.

Question—Do you think the question of colour for the seaman important?—Not so important as for the officer.

Question—Supposing a vessel suddenly emerged from a fog, and a green light was seen on the port side and a red one somewhere else, would it be necessary for the look-out man in that case to say where the green and red light was?—Yes, it would be of great importance if he could.

Question—Supposing you had a foreigner, say a Welshman, who only knew Welsh, if he sang out the Welsh for red, which I believe is very like green, would it not be nearly as bad as if he were colour-blind?—Quite.

Question—And then take the case of a German seaman, for instance?—They all understand the colours. We should not ship him unless he had sufficient experience to know port from starboard and red from green, and was familiar with the English expressions for them.

Question—If you rejected him he could probably be shipped somewhere else; I presume you think the company or vessel might be at a disadvantage by shipping a man who was colour-ignorant although not colour-blind?—Yes.

Question—There seemed to be some doubt as to whether it was necessary for the look-out man to have perfect vision for colour and form?—It is most necessary (especially when in close proximity to a light, and the vessel perhaps altering her course). The look-out man should sing out immediately red or green light, as he may see it before the officer on the bridge, should a sail, for instance, happen to hide it from him.

Question—Do you know of any accidents that have been traced to absence of colour-vision?—I cannot say we have traced one actually to it, but we have had suspicions about it, and they naturally have led to special enquiry. In addition to the case I have mentioned there was another officer, a second officer, who, upon being questioned, was found to have his sight affected. In all such cases we insist upon their leaving.

Question—With regard to shipping Lascars, you say they do not take look-out duty?—They are a sort of assistant look-outs; they have no responsibility, as that always rests with a European. There are generally two on the look-out together, one European and one Lascar. As a rule they pick up a certain quantity of English, and they have very good eyesight, though I do not know as to their colour-vision; they do not go through any examination. Between the two, that is to say the European who has picked up a certain amount of Hindustani, and the Lascar a certain amount of English, there is an understanding between them.

Question—Do you think the precautions taken by the Board of Trade with regard to seamen are sufficient?—I would not say they are stringent enough. They examine by means of coloured lights in a narrow passage, and the man has to call the colours. The naming of colours I consider to be a right test, as well as matching colours, on account of cases of colour-ignorance. Seamen might not know the names of all colours possibly; but as long as they name red and green without mistakes, that would be sufficient.

Question—Have you ever met anybody who called a light a black light?—No.

Question—Do you consider that the coaching for the Board of Trade certificate, which is known to be practised, might be the cause of the comparative ease with which defective colour-vision men get the certificate?—I do not think the coaching is sufficient to account for it.

Question—Does your examination include coloured lights?—No, coloured wools only; the Board of Trade use the coloured lights.

Question—We may take it that you examine all the officers, and you accept the Board of Trade shilling certificate for the men?—Yes, we always insist upon that. All officers, from the first to the fifth, go through our tests.

Question—Have you any suggestions you would like to make with regard to the tests?—I think not, except that the Board of Trade cannot be too severe with their examinations, and a little strong pressure might be brought to bear upon them in this direction. We should be glad to have the examinations made sufficiently reliable to relieve us of the necessity of doing what they ought to do.

LETTERS RECEIVED BY THE COMMITTEE BEARING ON
THE ENQUIRY.

"No. $\frac{7680}{1602}$

"Pall Mall,
"27th May, 1890.

"SIR,—I am directed by the Secretary of State for War to acknowledge the receipt of your letter of 20th instant, and to acquaint you in reply, that tests for Colour Vision are invariably used in the case of all candidates presenting themselves for Commissions in Her Majesty's Service.

"Holmgren's wools being the most convenient, are employed in a systematic manner to detect any defect.

"The plan consists in making the candidate match certain test colours from the heap of wools.

"I am to add that recruits are not tested for Colour Vision.

"I have the honour to be, Sir,
"Your obedient Servant,
"RALPH THOMPSON.

"The Secretary to the Committee,
"Science and Art Department,
"South Kensington."

"No. $\frac{7680}{1604}$

"Pall Mall,
"5th June, 1890.

"SIR,—I am directed by the Secretary of State for War to acknowledge your letter of 2nd instant, and in reply to acquaint you that there are no statistics regarding Colour Blindness compiled in this Department.

"I have the honour to be, Sir,
"Your obedient Servant,
"RALPH THOMPSON.

"The Secretary to the Committee,
"The Royal Society,
"Burlington House, W.