manding six officers and dismissing two of them their ship they had done their duty. The official account of the court-martial does not say how they rewarded the defective-sighted look-out man; for all we are aware he is still on the look-out for some more phantom ships, and I have very little doubt but that when found he will do his best to make use of them.

And now I must bring this paper to a close. Were it not that I have no right to encroach further, nor even for so long, on your time, I could relate other cases, each of which has some special feature; but I trust the additional evidence I have brought forward will be deemed sufficient to justify the medical profession in continuing to press the Legislature for precautionary measures. Individual companies are now doing what they can to obviate those preventable dangers arising from defective eyesight or colour-blindness in their sailors; but individual action is not enough, and it is deplorable that the Government of the country has not taken the subject up and settled it once and for all. The means recommended by their Select Committees for the Prevention of Collisions at Sea and for the Prevention of Loss of Life at Sea are and must remain futile, so long as they continue to ignore the very essential of safety—namely, perfect eyesight—on the part of officers and men. Surely it would be wiser to avoid danger than to provide for it.

There has recently sailed from this city of Glasgow a vessel² which may well be considered an ornament and a credit, not only to the men who designed and built her, but also to the nation to which she belongs. We can rest assured that the company to which she has gone will take every care that she is manned by men of good quality, and free from all physical defects such as colour-blindness and defective sight. In their hands she will be safe from all the perils of land, of rock, and of shoal, for she has simply to be kept away from them and she is secure against the worst of weather; but all the vigilance and care on the part of her officers and men cannot prevent her from being run into, if, on the colliding vessel, colour-blind or defective-sighted men hold the command, and that such a possibility should exist is, to my mind, a disgrace.

The subject is not a medical one; it is a national, or rather an international one, and the keen interest manifested by the public, as instanced by the copious correspondence following a suggestion that a possible factor in the cause of the railway disaster at Arlsey Junction was colour-blindness on the part of the engine driver, or by the equally copious correspondence which followed an excellent leading article on colour-blindness in the *Times* of December 6th, 1881, is to my mind sufficient evidence that were the facts (1) that there is no official test whatever as to a sailor's eyesight; (2) that a man may be the subject of any of the various forms of eye disease, may have any degree of blindness, or may be so shortsighted as to be unable to see distinctly more than a few inches in front of his nose, and yet be at perfect liberty to be a sailor, and to become an officer; (3) that although there is a compulsory colour examination—in many cases a most inefficient one—to be passed before a sailor can become an officer, there is no check to a colour-blind man being a sailor, or to his remaining one to his life's end; that were these facts placed fairly before them, public opinion would obtain for the subject of "sailors and their eyesight" that attention which so far the medical profession has demanded in vain.

² City of New York, Inman and International Line.

MEDICAL MAGISTRATES.—In a list of gentlemen appointed Justices of the Peace for Lanarkshire there occur the names of John Henry Beath, C.B., M.D., Hillhouse, Hamilton, and John Forrest, M.D., Calderview, Motherwell.

BEQUESTS.—The bequests of the late John Griffith, of 6, Hanover Terrace, Regent's Park, who died on September 21st, aged 91, include £4,000 to the London Hospital; £4,000 to Guy's Hospital; £4,000 to the Middlesex Hospital; and £4,000 to St. Mary's Hospital, Paddington.—Those of the late Mr. William Adam, of No. 3, Tenterden Street, Hanover Square, who died on July 27th at Forfar, include £500 each to St. George's Hospital, King's College Hospital, Middlesex Hospital, St. Mary's Hospital (Paddington), and Charing Cross Hospital; £600 to the Hospital for Incurables (Putney); £400 to the Association for the General Welfare of the Blind; £300 each to the Hospital for Epilepsy and Paralysis (Regent's Park), St. Thomas's Hospital, the Hospital for Diseases of the Throat (Golden Square), the Infirmary at Forfar, and the Cancer Hospital (Brompton).

COLOUR-BLINDNESS, WITH DEMONSTRATIONS OF NEW TESTS.

Read in the Section of Ophthalmology at the Annual Meeting of the British Medical Association held in Glasgow, August, 1888.

By KARL GROSSMANN, M.D.,

Ophthalmic Surgeon to the Stanley Hospital, Liverpool.

To employ people in positions for which they are, for some reason or other, unfit, is not a wise action; but when such a post on which the welfare of life and property depends is entrusted to anyone completely incompetent, such a proceeding is unjustifiable, not to say reckless. To urge before you the great dangers arising from the employment of colour-blind individuals as railway servants and seamen would be quite superfluous, as no one here could possibly be of a different opinion. Any contribution, however, which will show to the laity at large that we are not mere "theorists," and that our grievances are well founded, will deserve the thanks of everyone, and all the more so if such practical *demonstratio ad oculos* acts at the same time as an easy means of detecting colour-blindness—a means which can be applied by anybody without special knowledge or assistance. I believe it is principally due to a want in this direction that the practical points in reference to colour-blindness have not yet been generally acknowledged.

But before demonstrating to you an apparatus constructed with special view to the points mentioned, I beg leave to make a few theoretical remarks on colour-blindness. I am not going to give you either a long history of the first observations on colour-blindness, from John Dalton onwards, nor do I intend to tire you by exposing at length the different theories on colour-perception. These are elementary points known to every medical student. For the sake of simplicity, I shall confine my remarks to-day to that kind of colour-blindness which is by far the most frequent, namely, red-green-blindness.

A colour-blind person may be defined as one who mistakes as alike, or nearly so, certain colours which appear quite different to the normal eye. Holmgren, modifying Seebeck's tests with coloured papers, uses a bundle of about 150 different coloured skeins of worsted, out of which all those similar to a given one have to be selected. It is clear that if the selection be large enough, a certain colour may be matched as identical with the test specimen. Stilling combined two such colours to form a pattern of the one on a ground of the other. By this way, a colour-blind eye will see a single colour only. Stilling had thus plates printed; and although he succeeded finally in overcoming the great technical difficulties in the reproduction, still his plates were not perfect, and failed often, and this principally from a theoretical mistake, for which I think I have found out the reason. I return to this point in a moment.

For convenience sake, I want to introduce here a new word: I will call "twin-colours" a pair of different fundamental colours¹ (both simple and in combinations) which appear identical to the colour-blind eye. It requires long and often repeated working with very intelligent patients, and the harvest is not over rich; still it gives us a fair insight into the way colours appear to them.

To mix pigments is the way Stilling pursued; and although this is in one sense the easiest mode, it has the disadvantage of producing subdued tints only. For brilliant colours I resorted again to aniline-dyed wools. The way I finally adopted for comparing colours easily is shown by this tail of wools (exhibited). It contains 102 colours, each arranged so that it is shaded gradually from dark to light, from knot to knot being of one shade. There are altogether 1,744 different tints. The mode of comparing colours here is extremely convenient, the only thing required is to pick out two colours which seem very nearly the same, and then to run the one tint along the shades of the other. On this plate which I pass round you will find a good collection of such twin-colours. In order to verify their apparent identity, I resorted to the mode adopted by Cohn, and embroidered letters of the different wools. Of the specimens I show here, let me draw your attention to some of the yellows and greens, which are particularly valuable, as I shall explain presently.

In searching through the colours, I found that to some pairs a third fundamental colour could be added, thus completing the

¹ Fundamental colours: yellow, blue, red, green.

twin-colours to triplet-colours; for instance, to green and yellow, a certain red. Here, on this plate (passed round), you see some of these triplet combinations. Soon, however, I observed the following: The red in its darker shades was not always satisfactory; it was acknowledged by some individuals, while others disowned it both in twin- and in triplet-combinations, and yet the yellow-green twins and the pale-red tints were equally good for all. In some cases, the red appeared exactly like the green or brown; in others, it was lighter, in others darker. Still, in all my cases, the brown, the yellowish-brown, and green, acknowledged by one was identical for all the others. There, then, was a problem which wanted solving. After several futile attempts, I at last found the following explanation. Some colour-blind persons do not see the spectrum in its full normal length, but shortened at the red (left) end. Therefore, not perceiving certain red rays of the spectrum, they would see a particular red, darker than some of their co-sufferers, whose spectrum is of normal length. Of course, as pigment (and dyes) are not pure like prismatic colours, a certain red will not appear black to them, but as a dark-brown; and a pale red or pink will contain so much white that there will be no darkening effect noticeable from the red component of that particular colour. On the other hand, the green did not appear affected by the length of the spectrum, and, therefore, all my colour-blind patients saw the yellow and green twin-colours alike.

This explains why some of Stilling's plates are theoretically unreliable. It shows us that for the purpose of such pseudo-isochromatic combinations, the darker or middle tints of red have to be avoided. I made some special use of this observation by embroidering letters, of which the following woodcut (Fig. 1) gives

Fig. 1.

an idea, as far as an illustration in black and white can do so. Three colours are employed—green, brown, and red. On a brown ground a P is formed of red wool. This P is completed to an R by a green tail (marked in the woodcut by a lighter shade). When I show this letter to one of my patients whose spectrum is of normal length, he says, "I do not see any letter, all is a blank to me." Another one, whose spectrum is shortened, recognises a P (dark on a lighter ground), and we ourselves see the R. The more the spectrum is shortened at the red end, the darker and more distinct appears the P.

It seems to me that herewith a step forward is made in the direction of explaining the difference between the "red-blindness" and "green-blindness" of the followers of the Young-Helmholtz theory. As for myself, I have never met with a case where red-blindness alone or green-blindness alone existed; I always found that an individual incapable of recognising red as such was equally insensible to green.² Everyone who would mix green and grey would also add reddish tints to those colours, provided the selection of shades and tints was sufficiently large. The only difference I could find up to the present was the one concerning the red end of the spectrum, and this accounted for the difference of twin-colours required in the different cases.

By the three-coloured letter described above we are thus enabled to know at once to which class our candidate belongs.

[As a parenthesis, I will add another less important reason,

while easier avoided, why red is not very suitable for letters or figures of twin-colours—namely, the variability of the daylight. As we all know, the sunlight is not white, but yellowish. Clouds alter the light very much, and fogs and smoke, abounding in our atmosphere, contribute their share to modify it, too. In my specimens, the red was hereby far more affected than the green and yellow—thus doing away with the apparent identity of some twin-colours.]

For these reasons^x most of Stilling's plates are not reliable. But also the wools used in twin-colours in the shape of letters or figures are subject to a very great drawback, and that is, they are very apt to fade. The colours are not only not fast, but fade differently. Some pinks, for instance, are completely altered by an exposure of a few minutes to the sun; the same with some mauves; and most of the other colours are affected to some extent. The amount of fading is different in every individual

Fig. 2.

colour, with the result that a letter originally quite indistinguishable becomes easily readable after a certain time by the mere exposure to ordinary daylight.

Also Holmgren's test is open to the objection that it can only be perfectly applied in daylight.

In order to obviate as much as possible these objections, I tried to construct tests for artificial light which would at the same time imitate the coloured signal lights as nearly as possible. I

Fig. 3.

experimented with different transparent and semi-transparent material, paper, tissue paper, gelatine, etc., and finally adopted coloured glass. Out of two pieces of different (twin-coloured) glass I cut small squares, and arranged them loosely between two sheets of plain glass, so as to form some mosaic pattern. They are kept in their position by four bands of glass cemented to the edges of the one cover-glass. A narrow metal frame keeps the

² I mean, of course, typical congenital colour-blindness.

whole together, and forms it into a slide, to be placed into a lantern. Fig. 2 represents this lantern when open. It consists of an almost cube-shaped tin box, about six inches high, six inches wide, and eight inches deep. It contains a small paraffin lamp with a reflector, both fitting into a socket in the bottom of the lantern. The top has an opening for the chimney. The back (invisible in the figure) opens so as to admit the lamp easily. The front is open, and contains several grooves to receive the carrier for the slide. A piece of ground glass is placed behind the carrier, and in the third groove a transparent coloured glass may be placed if needed. The slide itself lies in front (in Fig. 2).

Fig. 3 represents the lantern when ready for use. The ground glass behind the slide makes the light more even, and allows the use of a very small wick. The construction of the slide will be readily seen in Fig. 4, as the lines in the woodcuts Fig. 2 and

Fig. 4.

Fig. 3 are somewhat misleading. Fig. 4 is a copy from a photograph, and shows very well the imperfect shape of the squares, due to my want of practice with the diamond. This photograph was taken from a light red and green slide. It shows very well how all these slides appear to the colour-blind eye. It is quite interesting to note, *en passant*, that the sensitive plate of the photographic camera is in this respect equally defective as a red-green blind eye. It is highly sensitive to dark and light, and registers apparently equal intensities of blue and yellow by differences of dark and light; but both slides and wool letters made of twin-colours for the red-green-blind came out as complete blanks when photographed. Want of space forbids me to go further into this matter here.

I must also refrain from giving here a detailed description of the different slides; a few remarks only may suffice. Some slides do equally well for lamplight and daylight, for instance, one of bright yellow and green; others for lamplight only, others again only for daylight. To the latter class belongs one slide which is interesting in so far as its material is taken from red and green signal glass. Seen in daylight, it appears to the colour-blind as one colour only, the only difference perceived being due to the circumstance that the green squares vary considerably amongst themselves in shade. In lamplight, however, this particular slide shows the green bluer and duller than the red, the latter thus becoming distinguishable. To equalise this difference, it requires only a transparent pale bluish-greenish glass to be placed between lamp and slide. This tint, however, was not to be obtained anywhere, and I had to stain the glass myself. In a similar way I stained glass yellowish red, to allow those slides which are twin-colours in lamplight, to appear as such in daylight.

There are also slides of triplet-colours. One of these is made of green, red, and brown. The colours are so chosen that the green and brown do equally well for lamplight and daylight, while the red completes the triplet for lamplight only. The red forms

a P, completed by brown squares to a B, the ground being green. This slide is therefore a complete blank in lamplight, while in daylight it shows a P to the colour-blind. I have also "pilot-letters," which every one must recognise; to demonstrate the letters and slides to the candidate, and there are also "trap-letters," to detect shamming.

I have thought of having my slides reproduced, not as fixtures but movable, so that at any time the examiner thinks it desirable, the slides could be opened and the letter or pattern altered. This would have the advantage that the candidate could never be certain what letter he would be shown, and no one of his friends could grind him beforehand in the different letters. Still there are several strong mechanical obstacles in the way; and this idea may therefore have to be abandoned. The carrying out of the manufacture of these slides is almost as laborious as that of my models, as hardly one foot in a big sheet of coloured glass is like another, and the most minute difference in shade is already detrimental. Still, if once perfect, the slides will last for ever. The small bits can scarcely be destroyed by anything, and their colour will outlive us all.

I should like to conclude with a few remarks on some practical points.

The tests at present applied by the Board of Trade are anything but satisfactory. They consist in coloured cards and coloured glasses, the names of which are asked. This may lead to wrong results in two directions: (1) it may prove too much, as the misnaming of these colours may be due to ignorance and not to colour-blindness; (2) it may prove too little, as colour-blindness by no means always prevents the correct naming of most colours, even if we could exclude guessing. Several of those who were not able to distinguish the letter in my red-green glass slide distinctly named the reds and greens of the Board of Trade tests quite correctly and without much hesitation.

Yet, there is another point I want to urge, and that is the examination for colour-blindness ought to be repeated periodically. Tobacco and other causes very often affect the keenness of sight, especially the colour-perception. This has been fully recognised in other countries, where the officials of many railway companies are examined not only periodically, but after each individual case of typhoid fever and other complaints.

Statistics are hardly wanted here, but for those who are very fond of them I will just mention that I have before me the most careful and elaborate statistics of seventy-nine German railways, comprising nearly a quarter of a million *employés* (239,726). One single point I will state: out of 16,201 cases of repeated examination 305 gave a result different from a previous one, and the report particularly emphasises the great importance of repeated examinations.

And considering how easily the examination for colour-blindness can now be carried out by anyone, it is greatly desirable that this defect, which in its typical form is a congenital affliction, should be detected at a period of life when the future vocation is not yet a settled affair, I mean at school. This would enable parents or guardians to prevent a colour-blind child from embarking on a career for which he is utterly unfit, and would thus save a great deal of time and expense.

I therefore sum up with the following points, namely: (1) in all schools (boys' schools at least) an examination for colour-blindness ought to take place at a certain time, say for instance at the age of ten; (2) every railway servant and sailor ought to be examined when entering the service; (3) these latter examinations ought to be repeated, both periodically and after special occasions.

Dr. REID asked whether the spectrum in those cases was shortened on the red end only, or whether there was a defect in the green too, and how the colour-blind sees the red and green; also whether there was a limit in the restriction of the shortening of the spectrum within which the triplet-coloured test could be applied.—Dr. GROSSMANN replied that in all his cases the red end only was shortened, where there was shortening at all. There was no discontinuation within the spectrum in the green portion. As for the triplet letter, it was intended for (and made with the help of) colour-blind people whose spectrum was of normal length.—Dr. MACKAY asked that in Board of Trade examinations more attention should be paid to the examination of the colour-sense eccentrically, with a view to determining whether hemiopic congenital colour-blindness was not sometimes present, and he indicated the value of such information towards the elucidation of the constitution of the visual centres.