Only two colours are visible in the spectrum to such persons, and these they term red and blue, in varying tones (see No. 3, Fig. 26). What they call red extends from extreme red through the orange and yellow as far as the yellow-green. Then where the normal eye sees blue-green and blue, the "green-blind" person seesonly grey, and their blue extends from the blue down to the violet (as shown in No. 3, Fig. 26).

To a "green-blind" person red and green both appear similar, *i.e.*, red, while to the "red-blind" person red and green appear tones of yellow, as shown in No. 2, Fig. 26. To both of them a red cherry or a scarlet poppy cannot be distinguished from the green leaves, except by their different forms. It is well to know, however, that colour-blind persons can be greatly assisted by viewing through suitably coloured glasses or gelatine films. For example, "red-blind" persons, by viewing through a green glass, can distinguish the difference between red and green, which they could not do otherwise. With the green glass the red object becomes much *darker*, almost black in tone, while the green is unaffected, and thus the two are readily distinguished.

For "green-blind" persons a piece of red glass or coloured film is required, which has the effect of making the *green* much darker, and thus separating it in appearance from the red. To a person who is *totally* colour-blind, *i.e.*, can distinguish no colour whatever, everything is a dull, neutral grey. The "spectrum" of the vision of such a case is represented in No. 4, Fig. 26. Fortunately, cases of absolute colour-blindness are very rare.

It is rather remarkable that there are very few cases of "violet blindness".

§ 49. It is possible, by means of wearing red or green-coloured spectacles for a considerable time, to render oneself temporarily colour-blind to the red or the green; but it is an experiment the writer would not recommend to dyers and colour-matchers whose eyesight and powers of colour-perception are too precious to be tampered with.

Dr. Burch, however, has experimented upon himself in this direction, and gives us some interesting details of his seemingly rather rash investigations. He exposed the eye to the glare of bright sunlight, behind a sheet of ruby glass, in conjunction with a gelatine film dyed with magenta, and thus rendered himself "red blind".

Scarlet geraniums, he tells us, looked black, and red roses blue. Exposure to green extinguished all green and yellow, but left the length of the spectrum unchanged. The exposure to yellow or "yellow blindness" is particularly interesting, as it can be confined to certain portions of the retina, and the red, green and yellow were extinguished. This result would seem to prove the Young-Helmholtz theory that yellow consists of red and green rays combined. This artificial "red blindness" lasted for some ten minutes, while the "violet blindness" continued for a day or more.

After thus experimenting, Dr. Burch found that it was with difficulty that he could match colours, and if a person made himself partially colour-blind, all colour matches would appear upset.

§ 50. It is rather a curious fact that "colour-blind," or, to be more correct, dichromic vision persons can often distinguish optical differences in colours which appear perfect matches to the normal or trichromic vision. For example, two shades of olive, one dyed with natural dyestuffs and the other dyed with the anilines, may match each other closely, and yet have a different optical structure, and present absorption spectra differing widely from each other. Though such shades appear similar to the normal eye, they will at once be observed by colour-blind people to possess different compositions.

An interesting example is given by Professor Church, F.R.S., where two green solutions were prepared, each appearing identical in hue to the normal colour vision. One solution consisted of neutral nickel chloride and the other acidulated copper chloride. A colour-blind person at once distinguished them as being different stuffs.

It would be rather an interesting fact to know if a person of dichromic vision could detect the small restored fragment restored in the ancient Egyptian sky-blue spherical cup in the Paris Museum, which we have already referred to in § 45, page 76. The author has no doubt whatever but the colour-blind person would at once point out the inserted fragment as showing a different colour, though to the normal colour vision it is of identically the same blue as the cup itself.

CHAPTER VII.

MATCHING OF SILK TRIMMINGS AND LININGS—BEHAVIOUR OF SHADES IN ARTIFICIAL LIGHT—MATCHING OLD FABRICS SOFT SHADES BY MIXING BRIGHT DYES—CHANGING OF MIXED SHADES ON EXPOSURE.

§ 51. **The Colour-Matching of Silk Trimmings, Linings, Facings, Bindings, etc.**—In the majority of coloured textiles, such as carpets, table-covers, curtains, calico prints, etc., we pay little heed to their colour appearances under artificial illumination like gas or lamplight.

If, under such conditions, any of the dyed colours show abnormal modifications in hue, we take it for granted that they could not be made to look otherwise. But every dyer and colour-chemist must, some time or other, have experienced the astonishment on viewing certain shades in gaslight, which in good daylight he compared and matched carefully. Many dyed colours are found to match perfectly in good daylight, and yet when viewed in gaslight they are found to be like each other no longer. This is a common occurrence, and, as a rule, the majority of dyers do not give much attention to the aspect of their shades under the artificial lights.

If we make our shades to match what is required in ordinary daylight, then we consider we have accomplished all that can possibly be required of us; and our shades, though altering very greatly in appearance in gaslight, may pass into customers' hands without any complaints being made about them.

But what about our less fortunate fellow colourists, like the dyer of silk trimmings, facings, linings, etc., whose shades *must* be made to appear exactly similar in artificial light to those he is required to match? Here, then, arises a special difficulty in colour-matching, of which the colourist for ordinary textiles happily knows little.

The dyer of silk trimmings and similar goods for ladies' wear generally gets a dyed piece of material, cloth or ribbon, as a specimen shade to which he must match the trimmings and linings to be dyed.

Before a perfect match can be made—perfect as regards the behaviour of the dyed materials under artificial light—the dyer must have some idea of the optical nature and properties of the dyestuffs which were employed in the dyeing of his specimen shade.

Suppose, for example, he gets a piece of dress material of a brownish drab colour dyed with fustin or fustic, an aniline grey like induline with perhaps a touch of methyl-violet, and he wishes to match it on silk trimmings or ribbon by dyeing with an aniline yellow and orange, with the addition of a little wool green or cyanine blue to flatten to the required shade.

By employing these dyestuffs he may be successful in getting a fairly good match in daylight to his specimen shade; but it will be impossible for him to get the two shades to look a match in gas or lamplight. They will present a wide difference in hue, the original piece of cloth appearing somewhat redder, while his shade, dyed to match, will appear of a decidedly *green* cast.

The case might also be the *vice versâ*, as the original shade to match might turn green and the dyer's shade become redder; but, so fastidious is the taste of fashion, that whatever shade the dress article may look like in gaslight—it may change much or change little—the dyer of the silk trimmings and linings must, under all conditions, make his shades to behave in every way similar to the dress stuff.

This, as many of our readers will understand, is no easy task. If the dyer of the dress material were also the dyer of the trimmings, etc., then of course little difficulty would be experienced, as the same colour stuffs employed for the one would do for the other; but as the dyer of the dress fabric is generally a different person from the dyer of the silk trimmings, the latter has to prepare his shades so as to match in every way the dress article.

This involves many difficulties which only the experienced dyer and colourist can appreciate, and though the shades may be matched to the best of the dyer's ability, they may be found faulty when examined in gaslight, and are then complained of as a "horrid" or a "beastly match" by the fair wearers.[1]

§ 52. The reader will find, in the dyed pattern No. 6 (see Appendix) a very good example of this difference in behaviour in apparently similar dyed materials. The piece of silk of the pattern No. 6 was dyed with—

5·0 per cent. naphthol-yellow,
0·5 per cent. acid violet,
0·1 per cent. acid violet 6 BN.

The small piece of woollen dress material attached, which matches the silk closely in daylight, was dyed with—

$7\frac{2}{3}$ oz. orange 4,
$5\frac{1}{2}$ oz. indigo substitute.

In ordinary daylight these two pieces of dyed material appear very similar, but if the reader examines them in an artificial light like gas or oil lamp, it will be observed that they present a very wide difference in appearance. The silk

[1] From a letter received by the author from a skilled dyer of silk trimmings and linings.

turns to a purplish brown colour, while the woollen fabric changes into a strong green olive.

And now let us suppose, for example, that a lady has a dress made of the woollen material similar to the small pattern attached at No. 6, in Appendix, and the dress is faced or trimmed with the silk material. In good daylight the dress will appear quite harmonious, and no difference will be observed between the dress and the silk facing. When worn in gaslight, however, the body of the dress would be olive green and the silk facings of a reddish drab colour, which would make a very unpleasant combination. Indeed, a person seeing the dyed specimens at No. 6 for the first time in gaslight could not imagine they would match each other in daylight.

It can be readily understood, therefore, that the subject of colour appearances under artificial illumination is a most important one to the dyers of ladies' cloth materials.

The writer has observed a lady's blue blouse, which was of a beautiful delicate blue in daylight, change into a dull-looking bluish drab in gaslight; while the collar and wristbands—dyed with a different dyestuff—retained their blue in gaslight. For other examples see Chapter VIII., page 92.

Pattern No. 5 in the Appendix, dyed with 5 per cent. Night blue, will be found to be a lovely blue even in gas or candle light.

An excellent practice adopted by many ladies is that of selecting *under an artificial light* the dyed materials which they wish to wear in such lights. By doing so, they will often escape the disappointment of finding that they cannot wear certain dress materials in gaslight.

In such cases as we have cited, where the gaslight aspect of dyed materials is of importance, the writer would strongly recommend the use of an orange-tinted gelatine film. By its use the dyer can see at once the "gaslight" aspect of the shades that are placed before him, and can learn whether they show any decided or abnormal modifications in hue.

For the employment of the orange-tinted film as an aid to dyers and colour-matchers, see § 44, page 75.

It is well to remember that in dyeing soft tertiary shades or "mode hues" by the combination of several dyestuffs, it is advisable always to employ somewhat dull colours for shading purposes. If clear bright dyes are employed and mixed with others to form dull shades, the shades so produced are almost certain to prove liable to change greatly in hue under artificial illumination (see § 53). It has already been observed in Chapter V., §§ 37-42, that the optical natures of the dyed fibre and the dyestuff employed exert a powerful influence in modifying the aspect of colours under gaslight.

From my own experience it has been found that *shades which owe their dulness or greyness to the absorption of light, produced by the combination of two or more bright dyestuffs having sharply defined absorption bands in their spectra, always prove more liable to show abnormal changes of hue in gaslight.*

As this subject has now become of considerable importance to every dyer and textile colourist, we have treated it specially in Chapters VIII. and IX.

§ 53. **The Colour-Matching of Old Fabrics.**—It sometimes falls to the lot of the colour-chemist to make a perfect match of some fine old piece of carpet, tapestry or print, and he will experience much difficulty in dyeing his shades to match those of the original which have become mellowed and subdued by age and exposure.

As I have said elsewhere,[1] "old coloured fabrics have a quiet beauty of colouring and a harmony of effect which

[1] *Dyer and Calico Printer*, June, 1899.

are well-nigh impossible to represent in a new material fresh from the loom.

"But many manufacturers who do not fully understand the difficulties—we might almost say the exasperating difficulties—of the textile colourist in making a perfect match, fail to see wherein the difficulty lies.

"But it is quite as reasonable, or shall we say unreasonable, to expect to find in a painting fresh from the artist's brush all the subdued harmony and the rich mellowness of effect seen in a Rembrandt or a Titan, a Raphael or a Domenichino.

"Coloured fabrics, like pictures and other luxuries, require to be 'seasoned' in order to develop that soft mellowness of harmony and effect which the colour-mixer finds it so difficult to imitate.

"No exact rules can be given to assist in the matching of shades subdued by age."

In restoring ancient tapestries in museums, where a new part requires to be pieced to the old, the new piece, after it is coloured, is gently dusted over with French chalk powder or soapstone. This gives a subdued greyness or faded appearance to the new part of the fabric, to make it match well with the old original material.

This device, however, is more the nature of a trick, and would not gain favour with textile colour-matchers.

The matching of the colours in old fabrics simply requires more than ordinary care, and a good eye for distinguishing the nicest variations of shade.

Colour-matching, like everything else, requires a considerable amount of patience, experience and skill. The experienced dyer and colour-mixer can tell almost exactly how a certain shade may be obtained; and can even give the relative proportions of the dyestuffs required to produce it.

§ 54. **Matching Shades Produced by the Absorption of Bright Dyes.**—Mention has already been made (see § 52) regarding the difficulty experienced in the matching of the dull soft shades which are composed of several bright and decided colours mixed together. Thus, for example, in producing browns, old golds and olive shades with a mixture of naphthol-yellow, or tartrazine, wool green or patent blues and orange, it will be found that the slightest excess of any one of the constituents at once knocks the colour off its desired shade, and often much difficulty is experienced in dyeing or printing each batch to match exactly the former lots. It is always difficult to match shades accurately when bright and luminous colours are combined to produce the effect. But, if softer and duller colours be employed for mixing purposes, such as azo-carmine, aniline grey or the indulines, indigo blues, patent fustine, etc., the shades produced by admixture are more readily brought up to the desired standard, as a slight excess either of the one or other of the constituents does not produce such a violent effect in altering the hue as with the more luminous dyestuffs.

§ 55. **Changing of Mixed Shades on Exposure to Sunlight.**—If a shade be produced by the combination of two dyestuffs, one a fugitive colour and the other fairly fast, it will, on exposure to sunlight, alter in hue owing to the disappearance of the more fugitive constituent. Thus, for example, a soft shade of mouse brown dyed with naphthol-yellow, methyl-violet and indigo carmine, will change after several months' exposure to the sunlight to a decidedly greener hue. This is owing to the disappearance of the methyl-violet, it being more fugitive than the others. There is thus left in predominance the yellow and the blue, which causes the exposed dyed material to acquire a much greener cast. It must often have been observed that the composite "indigo blues," composed of malachite or China green and methyl-violet, become very much greener, quite blue greens, on exposure to the sunlight. This is owing to the same cause, *i.e.*, the disappearance of the violet constituent. A window curtain dyed olive with tartrazine, orange and an aniline green was found, after long exposure to the sunlight, to have changed into a yellowish old gold colour, owing to the fading of the green constituent, thus leaving the yellow and orange to predominate.

CHAPTER VIII.

ASPECT OF COLOURS UNDER ARTIFICIAL LIGHT—ELECTRIC ARC AND MAGNESIUM LIGHTS—DUFTON-GARDNER LIGHT—WELSBACH — ACETYLENE — ORDINARY YELLOW ILLUMINANTS—TESTING MATCHING QUALITIES OF AN ILLUMINANT.

§ 56. **Aspect of Colours in Artificial Light.**—The change in appearance which dyed fabrics undergo when viewed in artificial light is now becoming a question of considerable importance.

When any colour composition is viewed under a yellow illuminant like ordinary coal gas or lamplight, the colours undergo a certain change in hue, varying in degree according to the quality of the light and the nature of the absorption spectrum of the dyestuff. If the absorption spectrum be of a normal nature, the colour, when viewed under a yellow illumination like gaslight, will present the *normal* modification aspect; but should the dyestuff possess a peculiar compound spectrum, or any special optical property, then it will present an "abnormal" appearance in gaslight. The following may be described as the normal colour changes observed under a yellow illuminant.

Aspect of Colours of Normal Spectra in Gaslight.

Reds	appear	brighter and like scarlets.
Scarlets	,,	brighter and like oranges.
Oranges	,,	lighter and like yellows.
Yellows	,,	lighter and fade towards white.
Bright Greens	,,	intensified and somewhat yellower.
Blue Greens	,,	like greens.
Blues	,,	duller and trifle redder.
Reddish Blues	,,	redder and like violets.
Navy Blues	,,	like blue blacks.
Violets	,,	redder, like claret reds, deepening to black.
Purples	,,	crimsons.

The above modifications are those generally observed when comparing the daylight with the gaslight aspect of ordinary colours.

If, however, the dyestuff employed in dyeing the fabric should possess any peculiarities either in the structure of its absorption spectrum, or in optical behaviour, then a marked difference from this normal gaslight appearance will be observed.

Two dyed fabrics, for example, may be a very close match in colour during daylight, and yet present a very wide difference in appearance in gas or lamplight, and *vice versâ*. Two shades can match each other perfectly in gas or lamplight and yet appear totally off the match when viewed in good daylight.

This is a difficulty with dyers and colour-matchers at the present day, which was not experienced before the introduction of the artificial or aniline dyestuffs.

All the natural dyes, such as indigo, archil, logwood, fustic, bark extract, cochineal, etc., change in the one direction, under an artificial light, *i.e., they all tend to become redder;* but with the aniline dyes, their multiplicity and peculiarity of optical structure give rise to no end of difficulty in colour-matching.

This is specially noticeable in compound tertiary shades, or "broken hues," where the several colour constituents have each their own little peculiarities of optical structure and behaviour. With bright red, orange, yellow and green colours, there is little difficulty experienced in matching in an artificial light, but such shades as drabs, olives, greys, blues, violets, slates, etc., are always liable to change greatly in hue.

There are some blues, such as Night blue, patent blue, cyanine, all of them tending to be greenish in tone, which keep their brilliancy remarkably well in gas or lamplight.

The dyed specimen No. 5, for example, to be found in

Appendix, is a beautiful blue (Night blue), and looks about as well in gas or lamplight as in daylight. This is owing to its absorption of the red end of the spectrum, and its free transmission of the green and blue rays.

The dyed patterns of scarlet, rhodamine pink and orange, to be seen in Nos. 1 to 4, are likewise little altered in appearance in gaslight; but if we examine the other shades, from Nos. 6 to 14, under an artificial light, we will at once observe great changes in their appearance.

With dyed specimen No. 6, for example, in gaslight the silk changes to a *brownish drab* or khaki shade, while the piece of dyed woollen cloth attached to it—though matching the silk in daylight—becomes a strong *olive green* shade, showing the widest difference in hue from the silk.

The reason for such strange modifications in hue is found after making a careful spectroscopic examination of the colour itself. Though the two shades are fairly like each other in good daylight, their absorption spectra, as we shall see further on, are very different (see p. 112).

For another example we may take two beautiful azure blues in solution. Let one be made by adding a little China or malachite green to a dilute solution of methyl-violet. This gives a fine azure blue in daylight, and it can be readily matched in colour with a solution of Prussian blue, obtained by adding a few drops ferrocyanide of potassium to a very dilute iron nitrate solution. The two blues, when examined side by side in a test-tube in daylight, are identically the same blue colour; but examine them in gas or lamplight, and a wide difference in appearance will be observed. The Prussian blue keeps its beautiful pure blue tone in artificial light, while the composite blue, made with green and violet, changes to a reddish lilac or an amethyst hue. If the solution be strong and deep enough it becomes almost a purple or magenta in lamplight.

This is a simple and characteristic case. By examining the two blue solutions with the pocket spectroscope, such as shown in Fig. 29, page 118, it will be observed that the Prussian blue absorbs the red end of the spectrum and freely transmits the green, blue-green and blue, while the composite aniline blue shows an almost free transmission of the extreme red and orange-red rays. If, therefore, these two colours be viewed in a light containing a large preponderance of red and orange rays —such as gas and lamplight—the colour, which readily transmits or reflects the red and orange, will necessarily appear much redder; while the other, absorbing the red rays, will, to a great extent, preserve an appearance almost similar to its daylight aspect.

The great majority of dyes transmit the red rays, while others transmit the green and blue rays more readily than any of the others; and from this fact arises much of the difficulty experienced in colour-matching, and of the abnormal modifications in hue under artificial illumination.

Suppose, for example, we have a simple carpet pattern done in a series of four fine rich browns, ranging from a deep seal brown, which constitutes the ground colour, to a light old gold shade of its lightest tint. If all the series be made in the same manner, with the same colour constituents, then no want of harmony or balance of the colour scale would be observed when the carpet was viewed in gaslight, or in fact any kind of illuminant. But let us suppose that the colourist dyed his ground shade with orange, fast red and aniline grey or induline, and in the lighter shades of the series he employed wool green, cyanine or patent blues for the saddening agent. The harmony of gradation of the scale may be faultless in daylight, but when the carpet is viewed in artificial light a total want of balance and harmony is at once observed. The lighter figures on the ground become very much greener, and no longer step in harmony with the ground colour which changes little in gaslight. Interesting examples of this are described in § 67 and represented in the coloured frontispiece.

It has been suggested to utilise this different appearance in gaslight of colours apparently similar in daylight by producing woven fabrics having the warp threads dyed by one class of dyes and the woof matching exactly the former, but dyed with colouring matters of different behaviour in gaslight.[1]

In daylight the fabric appears to the eye all of one uniform colour; but when viewed in gaslight a design of a different colour appears on it, produced by the dyed threads changing differently in hue under the artificial illuminant. For example, before me as I write lies a piece of ladies' cloth material showing—under gaslight—a coloured design, *i.e.*, figures of old gold upon a ground of a dull pink or reddish plum colour. When viewed in daylight, however, this material is all of one colour, namely, a brownish drab or khaki shade.

Many examples of differences in behaviour in apparently identical colours are constantly met with in the every-day duties of the dyer, and, as we have already seen in §§ 51, 52, give rise to much trouble in colour-matching.

Before proceeding further it may be well to describe briefly the different effects that the various artificial illuminants have on colour appearances.

§ 57. **Electric Arc Light.**—No doubt every textile colourist and colour-matcher must have felt the great need of a good artificial light that can show all colours in their true daylight aspect.

Most of our large dye houses and colour laboratories are fitted up with the electric arc light, which gives a beautifully clear and brilliant light, and forms in most cases an excellent substitute for daylight at night or in the dark winter months.

[1] See *Manual of Dyeing*, by Dr. Knecht, Rawson and Loewenthal, p. 883.

But every colour-matcher must have experienced that the electric arc, though undoubtedly very good, does not present many of the dyed colours in their true daylight aspect. It has often been found that colour matches made under its light require to be considerably altered when daylight comes. This involves serious expense and loss of time.

This is found to occur not only in the dye house but often in paper mills, where a sample of tinted paper requires to be matched while the machine is running at night. What seemed a perfect match in the electric arc light might be found the next morning to be faulty and requiring to be tinted over again.

The ordinary fundamental colours, such as red, orange, yellow, green, blue and violet, may be matched with all safety in the electric arc light; but it is when we come to examine compound shades, such as light drabs, citrines, olives, greys, slates, etc., or the innumerable broken tints, that we find its deficiency.

If we examine under the electric arc the compound dyed shades to be found at Nos. 6 to 14 in Appendix, we will observe a considerable difference in their appearance from that of their daylight aspect.

The light obtained from burning magnesium ribbon (see § 58) is even better for matching than the arc light, but even with it some few shades do not appear exactly as in daylight.

A dull greenish *olive* shade dyed with indigo blue, archil and fustic, presents in daylight a wide difference in appearance from a dull *russet* shade, dyed with aniline orange G., naphthol-yellow and wool green. Yet under the electric arc light they appear fairly similar, but with this difference, that the olive shade appears *redder* than the russet—a result exactly the opposite from daylight. It is only when the shades are examined "overhand" way, *i.e.*, by transmitted light (see § 35), that their true daylight aspect can be distinguished under the arc light. This fact applies also to the magnesium light (§ 58).

Although most colourists are aware that the electric arc differs slightly from daylight, yet the general opinion is that the arc light is too rich in blue and violet rays. Several writers on the subject have also held the same opinion, and even gone the length of recommending colour-matchers to use *yellowish*-tinted glasses to absorb the slight excess of blue and violet.

But had these writers only tested for themselves the effect of the arc light on the aspect of colours, they would have found that the facts of the case were exactly the opposite.

The present writer pointed out several years ago that glasses of a slightly *bluish* tint were required to give to the electric arc light a truer daylight effect by absorbing the slight excess of the less refrangible red and yellow rays.[1] But if the shades be examined by the "overhand" method as already mentioned, a very good idea of their true daylight aspect is gained.

In order to overcome the disadvantages of the arc light to the textile colour-matcher, two investigators, Messrs. Dufton and Gardner, have, after much careful experimenting, introduced a specially tinted copper-blue glass globe for surrounding the electric arc, and thus making its light in exact harmony with good daylight (see further the Dufton-Gardner light for matching, § 59).[2]

We have already observed, in Chapter II., §§ 12-23, that daylight is most variable in its nature, scarcely one hour of the same quality. Such a light has, unfortunately, to be discarded by the scientist in his accurate researches in colour

[1] *Journal Society of Dyers and Colourists*, November, 1896, No. 11, vol. xii., "The Examination of Colours, and their Appearances under the Artificial Illuminants".

[2] *Ibid.*, November, 1900.

physics, and the steadier and more reliable electric arc light is taken as the standard.

§ 58. **The Magnesium Light.**—The brilliant white light produced by burning magnesium wire or ribbon is most useful to colour-matchers who have not the electric light at their disposal. During dull, foggy weather in the winter months, or during night work, the colourist, by burning magnesium, may get a very good idea of the true daylight appearance of shades.

For the purposes of colour examination, in dye houses, paper mills, colour laboratories, etc., various types of magnesium lamps are sold, which, by means of clockwork, can be made to emit its brilliant light for half an hour or more. But to dyers and colour-matchers who are skilled in observing at a glance any differences in shades, such lamps may almost be dispensed with, as a foot of magnesium ribbon held with pincers by an assistant, or even by the colourist himself, answers the purpose equally well.

The aspect of shades under the magnesium light are in the great majority of cases identical to that of daylight. It is only when the shades are of the abnormally sensitive class, such as we have described in §§ 56, 57, *i.e.*, compound drabs, greys, olives, etc., that a slight difference is noticed from their daylight appearance.

To the eye of an observer the magnesium light, like that of the electric arc, appears of a decidedly bluish tinge, but when tested with several of these extra sensitive dyed colours its effect is that of a light having the slightest excess of orange rays in comparison to the daylight.

It is rather an interesting fact that all very brilliant illuminants, such as magnesium light, electric arc, Welsbach incandescent, acetylene gas and oxyhydrogen lime lights, all appear to the eye of a bluish or greenish tinge, and yet they all show in colour-matching an orange or yellowish effect.

Several theories have been propounded to try and explain this, but the true reason still remains doubtful.

To many dyers the magnesium light is of much help in making, what we might term, "snap-shot" examinations of dyed shades during the dark months, or after good daylight has gone.

It has already been mentioned (§ 57) that, with colours very sensitive to change in artificial light, the truest daylight aspect is obtained by viewing them "overhand" method (§ 35).

Investigations made on this subject by the writer show, from the colour-matching point of view, that the magnesium light is slightly superior to the electric arc, but both illuminants prove valuable aids to the colourist.

§ 59. **The Dufton-Gardner Patent Light for Colour-Matching.**—This valuable improvement on the arc light, briefly alluded to in a previous paragraph (§ 57), is the result of a long series of experiments by two well-known colourists, Messrs. Arthur Dufton, M.A., B.Sc., and Walter M. Gardner, F.C.S., of Bradford Technical College. It consists in surrounding the electric arc light with a specially tinted blue-copper glass globe, which absorbs the exact amount of the preponderating red rays from the arc light, and thus renders it similar to good daylight.

Their first attempts to modify the electric light so as to bring it into exact harmony with daylight were like to end in failure. In an interesting article in one of our dyeing journals,[1] the authors tell us that, after fruitless experiments with a great variety of blue and green colours, they found that the desired effect could be produced by the use of a dilute solution of copper sulphate, which has sharp absorption in the deep red, extending with diminishing intensity into the yellow-green, and great transparency for the blue and violet.

[1] *Journal Society of Dyers and Colourists*, November, 1900, No. 11, vol. xvi.

Having determined the exact shade of blue required for a certain lamp, they next turned their attention to the production of a blue cupric glass of the same tint. This they found was equally effective, and an electric arc light, surrounded by a globe of the proper tint of blue-copper glass, gives a light of exactly the same character as daylight for colour-matching. The new light has been subjected to the most severe tests, *i.e.*, by examining a series of coloured fabrics dyed with the dyestuffs most liable to change in artificial light, and also by direct comparison with daylight, and in every case the modified electric arc light agreed exactly with daylight.

No other artificial light that we know of can undergo such crucial tests. In every branch of dyeing and colour industry, where shades have to be carefully examined, this Dufton-Gardner light, which may now be obtained in the form of a special lamp,[1] will undoubtedly prove of great assistance.

§ 60. **Welsbach and Acetylene Gaslights.**—The other artificial illuminants which come next to the magnesium and electric arc lights in regard to their usefulness for colour-matching are the various forms of the "Welsbach" or incandescent gaslights and the acetylene gaslight. The incandescent lights on the Welsbach principle are a great improvement over the ordinary gas, but though their light presents to the eye a greenish or sickly look, they nevertheless contain a considerable excess of red and yellow rays compared with the electric arc and magnesium lights.

By viewing the shades in the "overhand" way, a much better idea of their daylight aspect may be gained, but this class of illuminants cannot be employed with any degree of safety while matching the sensitive and changeable shades

[1] From Jandus Arc Lamp Electrical Lamp Co., Ltd.

such as we have often had occasion to refer to in the previous pages.

All such illuminants show too great a predominance of the red and orange rays, with a corresponding deficiency in the blue and violet. A simple method of determining the colour-matching qualities of any illuminant is to examine under its light a few crystals of pure sublimed anthracene ($C_{12}H_{14}$). The crystals in daylight possess a beautiful violet or amethyst-coloured fluorescence which is invisible in yellowish or orange-tinted illuminants. From my own experiments there seem only to be three artificial lights capable of showing as in daylight this delicate violet fluorescent colour, and these are the magnesium light, electric arc, and the Dufton-Gardner lights. Under all other illuminants this beautiful violet tinge is lost.

The tabulated results on the next page show the different effects that the three lights, *i.e.*, electric arc, "Welsbach," and acetylene gas, have upon the aspect of dyed shades. It must be noted, however, that most of these shades, *i.e.*, from IV. to VIII., are of the super-sensitive class.

§ 61. **Acetylene Gaslight.**—The extreme brilliancy of the flame of this interesting illuminant has naturally suggested the idea that its light might be employed by dyers and colour-mixers for matching their shades when daylight is not obtainable. Indeed, it has often been recommended for colour industries—where the finest variations of shade have to be distinguished—as a "perfect substitute for daylight," and as "showing colours in their true aspect".

This, however, is a prevalent misconception. The acetylene gaslight possesses many interesting and valuable qualities as an illuminant, but unfortunately this important feature of showing the true daylight aspect of colours cannot be assigned to it. Strange as it may appear, all shades when examined under the acetylene light show the effects of being illuminated with a light having a slight excess of orange rays.

TABLE SHOWING THE EFFECTS OF DIFFERENT ILLUMINANTS UPON THE ASPECT OF DYED SHADES.

	Daylight Colours.	Composition.	Arc Light.	Welsbach.	Acetylene.
I.	Olive	= Archil, indigo, fustic.	Same as day	Not so green	Redder
II.	Indigo blue	= Patent blue, orange, chromo trop.	Same as day	Trifle greener	Much greener
III.	Indigo blue	= Archil, indigo, naphthol-yellow.	,,	Trifle redder	Much redder
IV.	Old gold	= Orange G., naphthol-yellow, patent blue.	,,	Greener	Much greener
V.	Moss green	= Naphthol-yellow, methyl-violet.	Trifle browner	Redder	More purple
VI.	Purple sage (Dichroic)	= Fustic extract, methyl-violet 3 B.	Trifle redder	Much purplier	Plum colour
VII.	Blue green	= Acid blue, cyanine, azo-yellow.	Same as day	Dull and red	Much redder
VIII.	Grey drab	= Fast red, azo-orange, wool green.	Trifle greener	Greener	Much greener like a sage

From an exhaustive series of experiments it has been shown that the acetylene light, however brilliant and pure it may appear to the eye, cannot be safely employed by dyers and textile colour-matchers.[1]

The delicate violet-coloured fluorescence of anthracene crystals, already alluded to in the previous paragraph as a good test for a suitable matching light, is invisible in acetylene light. Many of the beautiful tints of blue and violet to be found in flowers like the forget-me-not (*myosotis palustris*), the common hair-bell (*campanula rotundi folia*), the hyacinth, the sweet violet, and many others, change greatly in hue in acetylene gaslight. The blues become lavender greys, the lilacs are changed to pinks, and the bluish purples become red violets. Under acetylene light the greenish aniline blues like methylene, turquoise and patent blues turn very much greener in hue, and indeed can scarcely be distinguished from greens. All the many sensitive compound shades, such as olives, drabs, greys, russets, citrines, slates, etc., also change greatly in appearance.

A somewhat amusing instance of the change of appearance under acetylene light may be given from the writer's own experience.

An exact representation of the beautiful skin of the leopard, with its tawny brown colour and its deep maroon spots, was wished to be reproduced upon a carpet. An accurate and careful match of all the colours was made by the dyer, the dull tawny colour being produced with orange, naphthol-yellow and wool green. In daylight the dyed shades were a perfect match to the leopard's skin, and the carpet by daylight was considered quite a success.

But there was considerable astonishment when the carpet was viewed in acetylene light, or in fact in any of the yellower illuminants. The beautiful tawny brown of the leopard was

[1] See "The Aspect of Colours under Acetylene Light," by David Paterson, *Dyer and Calico Printer*, March, 1896, also *Journal Society Dyers and Colourists*, 1896, No. 11, vol. xii.

changed into an *olive green*, quite a novel colour for such an animal.

The original skin of the animal showed little change in its appearance in artificial lights.

If the tawny brown colour had been dyed with perhaps some of the vegetable dyestuffs like fustic and archil, or fustine and some of the aniline brown dyes, a shade could have been obtained to keep its right colour like the original even in the artificial light.

Examples such as this prove rather perplexing to the anxious dyer and colour-matcher, but we hope in the following pages to explain the causes which give rise to such differences in behaviour, and thus endeavour to assist him in his difficulties.

If the reader wishes a more exhaustive account of the behaviour of different colours under the acetylene light, he may consult the two articles already mentioned in the footnote of previous page.

§ 62. The ordinary illuminants like *coal gas*, *oil lamp*, *electric glow lamp* and *candle light* are all too rich in red and orange rays to be of any service as a substitute for daylight in colour-matching.

They are nevertheless of value to the colourist, as by viewing shades in such a light he can often discern peculiarities of hue and optical behaviour that would otherwise totally escape his detection in daylight.

Thus, gas or lamplight may be employed with advantage in examining the blue, violet and green class of colours, and also many compound shades, as slight differences in hue or in optical structure, which might be overlooked while matching in white daylight, become so accentuated under an orange illuminant as to be at once apparent.

For example, two blues may match each other closely, but one may have the very slightest tendency to be more of a violet hue; under gaslight their difference becomes at once visible. The latter shade is turned much redder.

Many similar examples might be given with greens, blue-greens and violets.

Every colourist knows the usual changes in appearance which ordinary colours undergo in gas or lamplight.

We have already described most of these modifications in § 56. Red and orange appear brightened, yellow seems to fade, and light tints of yellow appear white, so that pale yellow and white are indistinguishable in a yellow or orange illuminant. The primrose and the white lily both appear the same tint, and pale yellow gloves cannot be distinguished from white ones. The beautiful class of pinks, such as the eosines and rhodamines, which owe that characteristic beauty to their bluish bloom, lose much of their blueness in gaslight and tend to appear more orange.

Greens, blues and violets, with all their intermediate hues, become more modified the nearer they approach to the violet end of the spectrum. This is owing to the great deficiency of the blue and violet rays in all the common illuminants.

Coal gaslight in comparison with daylight contains only about 20 per cent. of the green rays, 10 per cent. of blue, and 5 per cent. of the violet rays. All colours, therefore, belonging to the blue and violet class must accordingly become altered in appearance under such a light.

There are some beautiful aniline blues, however, such as Victoria blue and Night blue (a dyed specimen of which will be seen as No. 5 in the Appendix), methylene and Nile blues, which will keep their clear blue colour remarkably well even in gaslight. This is owing to their absorption of the red rays, and the free transmission of all the green, blue and violet ones. Consequently, such blues, even when illuminated with an artificial light, preserve to a great extent their beauty of hue.

It will always be found the case when the coloured rays reflected by any colour are confined to one certain portion of the spectrum, either red, yellow-green or blue, that such colours do not show a great modification of hue under any of the ordinary artificial lights. If the blues contain a quantity of red in their composition, then they are certain to change in hue in gaslight.

A splendid bright green, which keeps its colour beautifully in any ordinary illuminant, may be dyed with three parts quinoline yellow and two parts acid green. Such a green dyed on silk is as bright and lustrous in gaslight as it is in daylight. By studying its absorption spectrum we find that it transmits, as nearly as possible, only the pure green rays about the lines E of the spectrum. Such a colour will keep its hue even in gas or candle light. In dyed pattern No. 6, in the Appendix, we find two colours very similar in daylight and differing widely in gaslight. The silk pattern shows a free transmission of the red rays, while the woollen material attached shows strong absorption in the red and free transmission of the green and blue rays. In daylight the optical properties of the two are about equally balanced, making what we term a "match". But, whenever these colours are examined under a light possessing a predominance of red and orange rays, then the equilibrium of hue is disturbed, the dyed silk is ready to transmit any amount of red rays; while the woollen material absorbs the red, and transmits more readily the green rays; consequently they appear in gaslight widely different in hue. The silk becomes a dull reddish brown, while the woollen material becomes a strong olive green. This is seen at once by viewing them in gas or lamplight.

Other examples, but less pronounced, may be found in the dyed pattern plates, Nos. 7 to 14, which are fully described in Chapter IX., pages 111-119.

We have already observed that the *compound shades* are very liable to show abnormal changes of hue in gaslight. Their "gaslight aspect" depends upon *the most changeable colour constituent in their composition.*

For example a slate blue dyed with azo-yellow, fast acid blue and cyanine blue, *reddens* considerably in gaslight, even though it contains cyanine blue, which turns much greener in gaslight. But the greening power of the cyanine blue—if we might so express it—is over-ruled or masked by the more sensitive fast acid blue, which *reddens* in gaslight, so that the resultant aspect is produced by the latter more changeable dyestuff. In a similar manner olives made with orange, yellow and wool green turn much greener in artificial light; but if a proportion of the wool-green constituent be replaced by methyl-violet 3 B, a similar daylight shade of olive is produced, which, however, becomes *redder* instead of greener in gaslight. This is owing to the greater changeability of methyl-violet than the cyanine blue in gaslight.

One of the worst illuminants by which to judge colours is the electric *glow lamp*, as it contains such an excessive predominance of the red and orange rays. Even the most experienced colourist may be completely deceived as to the true aspect of the shades examined under it. It is a wise plan, which many ladies adopt, to select by gaslight or the electric glow lamps of the shops those dress materials and colours which are intended only for evening wear.

Many a person might thus be saved the disappointment of finding that some beautiful soft shades selected in the daylight become crude and disappointing in the gaslight, and likewise the converse.

A somewhat amusing instance occurred to the writer himself, and even at the very time he was specially engaged in the study of colour appearances under artificial lights. Going to stay with a friend, he wished before doing so to purchase a silk neck-tie, and selected, under the light of the electric glow lamp in the shop, one which seemed to him of a remarkably chaste and refined pattern. It was of a beautiful soft dove-grey with a white stripe. Imagine his surprise and humiliation next morning when it turned out to be a garish *peacock blue with a yellow stripe.*

Under the strongly orange-tinted illuminant, yellow could not be distinguished from white, and such a light being so greatly deficient in the blue and violet rays, caused this certain blue to be so saddened as to appear a soft grey.

§. 63. **Testing the Matching Qualities of an Illuminant.**—In order to test an illuminant for its colour-matching qualities, it is necessary to examine under its light a selection of coloured materials which show abnormal colour changes under gaslight. The delicate tints of blue and violet to be found in many varieties of common flowers, such as the hare-bell, hyacinth, forget-me-not, sweet violet, the delphiniums, etc., are very sensitive to any artificial illumination, and form useful *test-colours*. The delicate violet-coloured fluorescence of anthracene crystals has already been referred to (see § 60) as a simple and delicate test for showing if an illuminant is of good colour-matching quality.

But perhaps the most practical *test-colours* are those delicate compound dyed shades produced with many of the aniline dyes. It is possible, by selecting certain classes of dyestuffs and combining them, to produce very sensitive shades, which change their aspect with even the faintest difference in the quality of daylight. Some of these shades alter in appearance with the time of the day; and what was considered a match in the morning is off the desired match in the afternoon. We have already mentioned compound shades of this nature (see §§ 51, 52), and the dyed specimens to be found in the Appendix, especially No. 6, and the pairs from 7 to 14, show interesting changes. It must be remembered, however, that in order to judge correctly the modifications which the dyed shades undergo in gaslight, we must have for comparison other shades, similar in daylight, which show little or no change of hue under such conditions. The differences in behaviour are then more accurately noted than if we depended solely upon the *memory* of their daylight aspect. It is well to remember, as we have already observed in the cases of the acetylene and Welsbach lights (§§ 60, 61), that the brilliancy and apparent whiteness of the illuminant to the eye cannot be taken as a guide to its colour-matching qualities.

CHAPTER IX.

INFLUENCE OF THE ABSORPTION SPECTRUM IN THE CHANGES OF HUE UNDER ARTIFICIAL ILLUMINATION—ABSORPTION SPECTRA OF TWO SAGES—TWO SLATE BLUES—TWO GREY DRABS—STUDY OF THEIR DIFFERENT BEHAVIOUR AND OPTICAL PROPERTIES—ABNORMAL MODIFICATIONS UNDER GASLIGHT.

§ 64. In the preceding chapters we have repeatedly referred to the abnormal changes in the appearance of many dyed shades when examined under artificial illumination; and we have also observed that this phenomenon is due to a peculiarity in the nature of the absorption spectra of the dyestuffs themselves.[1] As this interesting subject is becoming every year of greater importance to all textile colourists, we intend now to devote to it a little special attention.

Two shades of a dull green sage can be obtained by dyeing in the first instance with methyl-violet and naphthol-yellow, and in the second instance, with naphthol-yellow, wool green S., and a trace of red or scarlet. The two shades so made may match each other accurately in daylight, but under gaslight, or any ordinary artificial illumination, they present a wide difference in appearance. The first shade dyed with violet and yellow becomes a *reddish-brown* in gaslight, while the other shade becomes an *olive*.

[1] The writer has shown that dichroism and fluorescence possessed by the dyes, and also the optical properties of the fibre itself, affect, in a slight degree, the "gaslight aspect" of dyed colours.—(See *Journal Society Dyers and Colourists*, November, 1896.)

In order to explain the strange difference in the behaviour of two apparently similarly dyed materials, let us examine the colours with the spectroscope.

No. 2 of Fig. 27 represents the appearance of the absorption spectrum of the sage dyed with naphthol-yellow and methyl-violet. No. 1 is the solar spectrum with all the hues in their normal intensity.

It will be observed that the shading in the diagram represents the absence or absorption of the coloured rays of the spectrum at that certain part. This absorption spectrum of No. 2 shows the sage colour to consist of the red and a portion of the green part of the spectrum, while the orange

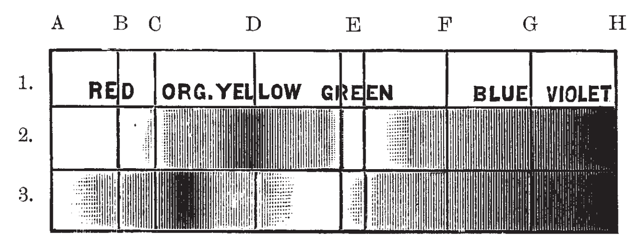

FIG. 27.—Showing the optical difference in structure of two shades of sage identical to the eye. No. 1 is solar spectrum; No. 2, absorption spectrum of sage produced with methyl-violet and yellow; No. 3, absorption spectrum of sage produced with yellow, wool green and small quantity of red.

and yellow at the D line, and the blue and violet from F to H lines, are all quenched or absorbed.

The strong absorption band at the yellow is caused by the methyl-violet constituent, while the absorption of the violet and blue rays is caused by the naphthol-yellow.

By looking at this absorption spectrum, it will be at once observed that the red from A to C lines is freely transmitted; while there is a decided tendency to absorption in the yellow-green and blue-green parts of the spectrum.

If now we view such a shade as this in a light which is deficient in the green and abundant in the red rays, like any of the ordinary illuminants, it will be readily seen that the shade presents a very much *redder* appearance, owing to its free transmission of the predominating red rays and its tendency to absorption of the deficient green rays.

Diagram 3, Fig. 27, represents the absorption spectrum of the other sage colour, exactly matching in daylight No. 2, but dyed with naphthol-yellow, wool green S. and a small quantity of red. It will be at once observed that it differs from No. 2 above it. In No. 3 there is strong absorption in the cherry-red between the C and D lines, caused by the wool green, and there is more or less a tendency to absorb a certain portion of the red rays. This is shown by the faint shading of the red, B to C in the diagram. The yellow-green and a considerable portion of the green rays are freely transmitted. This, it will be observed, differs greatly from the spectrum of No. 2.

Then follows the gradual absorption of the blue and violet similar to that of No. 2 spectrum.

By comparing in this manner these two spectra of shades, apparently identical to the unassisted eye, the spectroscope has thus revealed the cause of the differences in their behaviour under gaslight.[1] Shade No. 3 shows a tendency to absorb the red rays at the B line, and a strong absorption of the cherry-red where the shade No. 2 shows free transmission of those rays.

Then spectrum No. 3 shows free transmission of the yellow-green where No. 2 shows strong absorption.

Thus, No. 3 shade, dyed with wool green, yellow and a little red, when viewed under an artificial light, will show a freer transmission of the yellow-green and green than No. 2; hence its gaslight aspect must be *greener*.

[1] It is unnecessary here to enter upon the principles underlying colour-absorption and of the theory of the spectroscope; readers are referred to Chapters III. and IV. of companion volume, *The Science of Colour-Mixing*.

By viewing the dyed pattern No. 6 in the Appendix, we may see a very good example of an exactly similar case. The silk pattern has been dyed with—

5·0 per cent. naphthol-yellow,
0·5 per cent. acid violet,
0·1 per cent. acid violet 6 BN.

The absorption spectrum is exactly similar in nature to that of No. 2 in Fig. 27 we have just described. The small piece of dyed woollen material attached to the silk matches fairly well with the silk, and was dyed with—

0·5 per cent. orange 4,
0·35 per cent. indigo substitute.

Its absorption spectrum closely resembles that of No. 3. If the two dyed fabrics be examined in gaslight, the widest difference in hue is observed, corresponding to that just described and explained.

The silk material having a spectrum like No. 2, Fig. 27, changes to a dull reddish-brown shade; while the dyed woollen material, having a spectrum resembling No. 3, becomes a strong olive green.

In the case of the dyed silk the modifying constituents are the acid violets, especially *acid violet* 6 BN, which reddens much in gaslight, and in the other instance it is the indigo substitute which becomes *greener*, and the orange disappears under similar conditions.

On examining the spectra of these sage colours shown in Fig. 27, it will be observed that they consist principally of red and green rays, greatly toned down or "saddened" by absorption of all the other rays of the spectrum. When we remember that a mixture of red and green-coloured lights produce the sensation of *yellow*, we at once see that this sage colour consists practically of a much degraded or saddened yellow, *i.e.*, a yellow mixed with a large proportion of grey. Then if this be so, we should be able to match such a sage colour by simply dulling yellow with a certain proportion of grey.

And this is so. A colour matching the two sages already described may be dyed simply with a yellow and an aniline grey, thus producing a shade of greenish sage.

It is needless to say that a shade thus produced does not show any abnormal changes of hue in gaslight where a more complex shade would. It has no peculiarity in its absorption spectrum, being merely a saddened or "broken" yellow.

A similar example to these sage colours will be seen at dyed specimens Nos. 13 and 14, which will be described as we proceed.

§ 65. The dyed patterns Nos. 7 and 8 (see Appendix) are two shades of deep slatey blue which appear fairly like each other in daylight, but in gaslight they present a wide difference in hue.

Dyed pattern No. 7 appears much greener in shade, while No. 8 is a very deep purply slate grey in gaslight.

If we study the absorption spectra of these two dyed colours, we find that No. 7 shows a strong absorption in the red part of the spectrum (lines B to C), while in shade No. 8 the red portion is largely transmitted. The absorption spectra of these tertiary shades, containing three or more different dye constituents, are often of a very complicated nature and difficult to analyse with the spectroscope. The little luminosity they possess, being merely greys with a predominating hue, greatly increases the difficulty. I have endeavoured, however, to represent the absorption spectra of these two shades in the annexed Fig. 28.

Spectrum A represents the absorption curve of dyed shade No. 7, while A′ represents the shaded spectrum corresponding in absorption to the curve above it.

This shade was dyed with—

1 kilo. patent blue,
80 grammes orange G,
20 ,, chromotrop 2 R.

The strong absorption in the red is due to the patent blue constituent, while that in the yellow, green, blue and violet is owing respectively to the chromotrop and orange dyes.

It will be observed from this absorption diagram that the green at the E lines is more freely transmitted than the red.

Spectrum B, Fig. 28, represents the absorption curve of the dyed shade, No. 8, and B′ the shaded spectrum, corres-

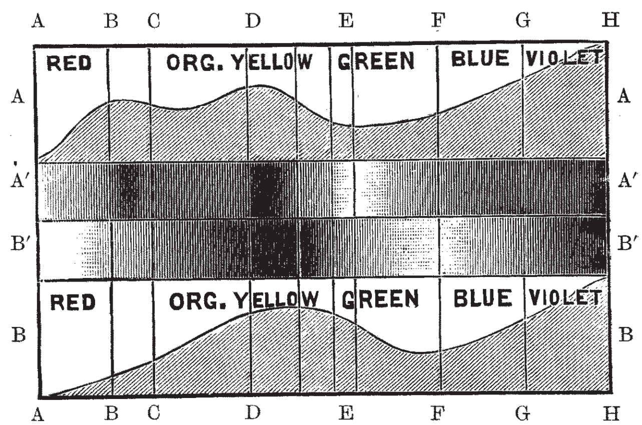

FIG. 28.—Showing absorption spectra of two similar shades of deep slate blue. A, A′, dyed with patent blue, orange and chromotrop. B, B′, dyed with orchil, indigo and naphthol-yellow. Both shades similar in daylight, but widely different in gaslight.

ponding in absorption to the curve below it. The two spectra A′ and B′ are brought close together in the diagram for the sake of easier comparison.

This shade was dyed with—

4 kilos. orchil,
2½ ,, indigo carmine,
2 grammes naphthol-yellow S.,

and it will be observed that it differs in construction from that of A′. The red is transmitted, while the green at E lines is strongly absorbed, due to the orchil constituent, and the blue-green and blue are transmitted.

These two diagrams, A A′ and B B′, Fig. 28, may be taken to represent the absorption spectra of the two dyed patterns Nos. 7 and 8, and from their study we can now understand the different behaviour of the two dyed materials under artificial illumination.

Shade A, dyed with patent blue, orange and chromotrop, shows greater readiness to transmit the green than any other part of the spectrum, and shows likewise absorption in all the red part of the spectrum. Such a shade, under an artificial light, becomes very much greener. For example, if we examine under gaslight the dyed pattern shade No. 7, we will see how the green predominates.

Shade B, Fig. 28, dyed with orchil, indigo carmine and naphthol-yellow, shows a free transmission of most of the red rays and strong absorption of the green at the E lines, owing to the orchil constituent. We can see from this that indigo, though a blue dyestuff, freely transmits the red rays as well. The absorption of the violet, blue-violet and blue is due to the naphthol-yellow constituent.

This shade when viewed under gaslight must become very much redder, as we can see from its spectrum B and B′ that the red rays are readily transmitted. It is owing to this fact, therefore, that the dyed slatey blue shade, No. 8 in Appendix, becomes much redder in hue in gaslight. In the spectroscopic examination of dyestuffs the small direct vision instrument shown in Fig. 29 will be found most useful. It can be carried in the waistcoat pocket.

§ 66. In dyed patterns Nos. 9 and 10 we have a very similar example. Both shades match each other and are of a dark plum drab in daylight, but in gaslight No. 9 appears a very dark sage grey, while No. 10 is a deep shade of plum, approaching a maroon. On analysing their construction, we find them to show the same properties as the two shades just described in Nos. 7 and 8, and this might be expected, seeing that they are dyed with similar groups of dyestuffs.

No. 9 was dyed with—

480 grammes patent blue,
300 „ orange,
355 „ chromotrop,

while No. 10 matching it was dyed with—

6 kilos. orchil,
2½ „ indigo carmine,
50 grammes naphthol-yellow.

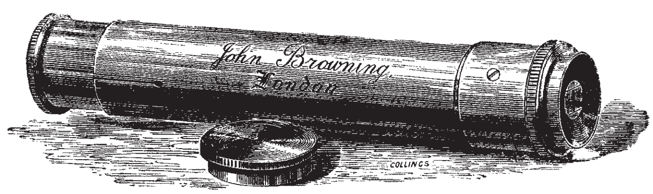

FIG. 29.—Direct Vision Spectroscope.

The patent blue constituent of No. 9 gives it the property of greening much under an artificial light, owing to the free transmission of the green and the absorption of the red rays possessed by this dyestuff.

On the other hand, the natural dyestuff, orchil, in No. 10, possesses properties of an exactly opposite nature, being strong in absorption of the green and free in transmission of all the red rays. The indigo or blue constituent of No. 10 also shows transmission of the red. We can readily understand, therefore, how two shades apparently similar in daylight to the unaided eye, but compounded of dyestuffs of different optical natures, are bound to behave differently under the yellow artificial illuminants.

The dyed specimens of subdued plum colour, Nos. 11 and 12, resemble each other fairly well in daylight and yet present a wide difference under gaslight—No. 11 appearing much flatter and more of a brown, while No. 12 becomes much redder, approaching a claret. The reason for this may now readily be understood from what has been said previously.

Shade No. 11 was dyed with—

220	grammes	patent blue,
220	,,	orange G. pat.,
560	,,	chromotrop 2 R. pat.

Under yellow artificial lights the orange disappears to a great extent and the patent blue becomes much intensified. The result is that the gaslight aspect of the colour is very much flatter or bluer, making it of a dull brown or russet colour.

With dyed specimen No. 12 the opposite effect is produced.

It was dyed with—

12	kilos.	orchil carmine,
1	,,	indigo carmine,
50	grammes	naphthol-yellow S.

As we have already observed, yellow disappears in a yellowish illuminant, while the natural dyestuffs, orchil and indigo, allow a ready transmission of all red rays. It follows that such a colour as shade No. 12 will naturally become very much redder in gaslight than its corresponding shade No. 11. A very striking difference in behaviour between two apparently similar dyed materials is found also in the two last dyed specimens, Nos. 13 and 14.

Pattern No. 13 was dyed with—

200	grammes	patent blue,
300	,,	orange G. pat.,
80	,,	chromotrop 2 R. pat.

The large excess of orange present in the dyed material as seen in daylight disappears greatly in gaslight, with the result that the shade instead of its being a soft fawn or khaki colour becomes a dull *sage green* under gaslight. The decrease of the orange, combined with the increase of the patent blue, produces this result. Pattern No. 14, which closely resembles No. 13 in daylight, becomes a *reddish drab* in gaslight.

It was dyed with—

3 kilos. orchil carmine,
1 ,, indigo carmine,
1½ ,, naphthol-yellow S.

From what has already been stated, one can at once predict how a colour of this composition will behave in gaslight. The indigo blue tends to redden in gaslight, in direct contrast to the patent blue, which becomes much *greener;* the orchil reddens greatly, while the yellow inclines to disappear. The results are that No. 13 becomes much *greener*, and No. 14 becomes much *redder* in gaslight than in daylight.

§ 67. The coloured plate (see frontispiece) represents some abnormal changes in hue of dyed fabrics. Fig. 1 shows a pattern done in two shades of olive, the dark ground shade dyed with naphthol-yellow, wool blue and methyl-violet, while the light shade of yellowish olive is dyed with yellow, orange and wool green, or patent blue N. In daylight the two olives appear of the same class and quite in harmony, but under gaslight their change of hue is very great, representing something like Fig. 2. The dark olive containing methyl-violet as a constituent reddens into a russet shade, while the light olive turns very much greener owing to the wool green or the patent blue constituent. The daylight appearance of the fabric, therefore, is widely different from that of gaslight, and may be represented somewhat like Figs. 1 and 2 of frontispiece.

Figs. 3 and 4 (frontispiece) represent the same phenomenon in a more curious aspect. The lightest shade of terra-cotta has not been made with the same dyestuff as the ground and the second shade. Though harmonising well enough in step in daylight with the general tone of the two other shades, in gaslight it goes quite off the cast (see Fig. 4), and becomes so green as to appear a distinctly different colour.

The ground and second shades were dyed with orange, azo acid magenta and indigo substitute BS, but the light tint had, in place of the indigo, the dyestuff wool green S. The harmony of colour gradation or "step" of the composition was faultless in daylight, as shown in Fig. 3, and all the shades appeared of the same nature and composition; but under artificial light the lightest tint at once stood out from the other colours as being of a different greener cast (see Fig. 4).

Of course it must be remembered that the examples we have chosen are somewhat exaggerated, and could scarcely be produced in actual practice unless through some gross carelessness of the dyer, or with the studied view of obtaining such curious results. Nevertheless it requires the utmost care in the proper selection of the dyestuffs to obtain a colour which behaves in all respects similar to the shade it is desired to match.

§ 68. **Unreliable Dyestuffs.**—While speaking of the difficulties of colour-matching, we cannot but refer to a very important question, *i.e.*, the varying and unreliable quality of some of the dyestuffs used.

As a rule, dyers and colour-mixers prefer to keep closely to their standard dyes, which they have found after long experience to be regular in strength and quality. They are naturally very slow—and rightly so—to adopt a new brand of dyestuff, even though it promises well in their trial experiments, because they have, no doubt, learned from bitter experience that many dyestuffs after being adopted prove to be uncertain in strength and quality of tone.

After colour recipes have been altered and adjusted to suit the new dyestuff, it may be found, on examining the next delivery of the stuff, to be slightly different in quality. This upsets completely the colour recipes, and gives the dyer no end of trouble in matching his shades to the required standards.

This is one of the most annoying experiences of the colourist. Month by month the dyestuff may creep almost imperceptibly off the correct tone unless the utmost vigilance be exercised.

It is very important that every colourist should keep a small sample of the dyestuffs as bargained for while making the contracts for the year, so that they may be kept for comparing with the future deliveries of the dyestuff.

But in the best regulated colour laboratories, and although the utmost care be exercised, it may be found that the dyed shades are not coming out just as they are desired. They may require to be altered and adjusted with one dyestuff or another to bring them to the correct shade, and it is here that the colour-matcher experiences most difficulty.

It is hard for any person not skilled in the practical mixing and matching of colours to believe that a dyestuff giving tones of colour almost identical to its required standard may, when mixed with other dyes to form compound shades, produce results very different from what were expected.

Yet, as every colourist knows, this may be so. For example, two shades of brown may appear identical, yet when each is mixed with a certain proportion of green or blue the two shades of terra-cotta thus produced may not be at all similar.

In the same manner two aniline greys or indulines may appear, when dyed by themselves, of exactly the same colour, yet if there be added a certain proportion of pink to form a soft purple, or a yellow to give a citrine, or an orange to give a russet, the resulting pairs of shades may differ considerably.

Some slight difference in hue between the two greys, not observable at first, becomes apparent on its admixture with other colours.

Here, then, arises a great source of difficulty to the colour-matcher; and it requires the colour manufacturers and their agents to thoroughly appreciate the importance of this subject, and to exercise the utmost care that all deliveries of dyestuffs are unvarying in strength and tone of colour.

At the present day, when business runs at high speed and everything is bustle and hurry, the colourist has no time to waste on altering shades and adjusting his recipes to suit a vacillating and uncertain dyestuff, no matter how anxious he might be to use it.

This subject is a most important one to dye manufacturers, and well worthy of their closest attention.

INDEX.

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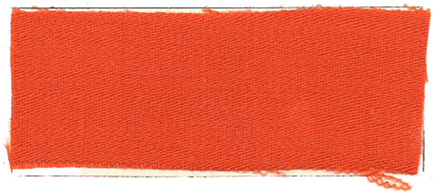
DYED SPECIMENS ILLUSTRATING TEXT, PLATE I.

(WEIGHTS ARE FOR 100 LB. WOOL.)

No. 1.



Dyed with
3· per cent. Orange 2,
0·25 ,, Azo Acid Magenta.

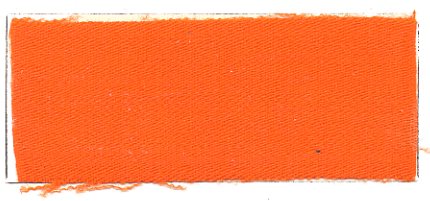
No. 2.

Dyed with
2 per cent. Rhodamine.

No. 3.

Dyed with
2½ per cent. Palatine Scarlet.

No. 4.

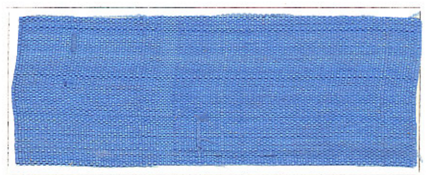


Dyed with
2½ per cent. Orange No. 2.

DYED SPECIMENS ILLUSTRATING TEXT, PLATE II.

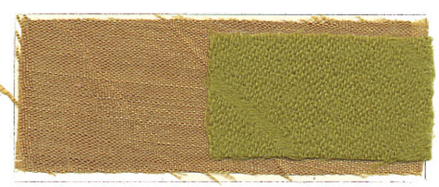
(WEIGHTS ARE FOR 100 LB. WOOL.)

No. 5.



Dyed with
5 per cent. Night Blue.

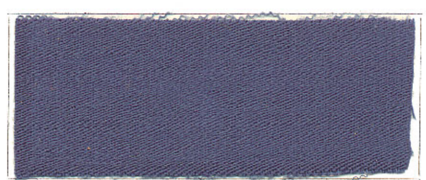
No. 6.



Silk Fabric dyed with
5· per cent. Nap. Yellow,
0·5 ,, Acid Violet,
0·1 ,, Acid Violet 6 BN.

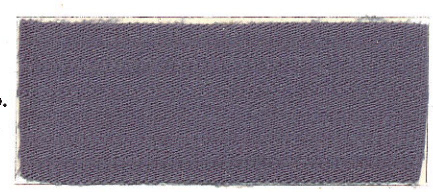
Woollen Fabric dyed with
0·5 per cent. Orange 4,
0·35 ,, Indigo Substitute.

No. 7.



Dyed with
1 kilo. Patent Blue,
80 grs. Orange G.,
20 grs. Chromotrop R.

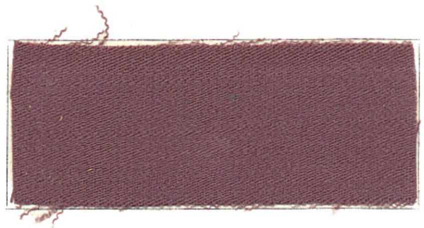
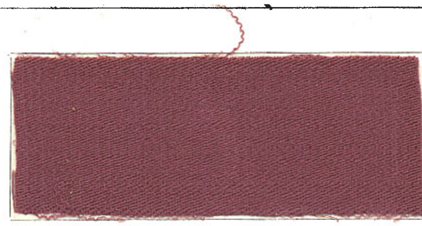
No. 8.



Dyed with
4 kilo. Orchil Carmine,
2½ kilo. Indigo Carmine,
2 grs. Naphthol Yellow.

DYED SPECIMENS ILLUSTRATING TEXT, PLATE III.

(WEIGHTS ARE FOR 100 LB. WOOL.)

No. 9.		Dyed with 480 grs. Patent Blue, 300 grs. Orange G., 355 grs. Chromotrop 2R.
No. 10.		Dyed with 6 kilos. Orchil Carmine, $2\frac{1}{2}$ kilos. Indigo Carmine, 50 grs. Naphthol Yellow.
No. 11.		Dyed with 220 grs. Patent Blue, 220 grs. Orange G., 560 grs. Chromotrop 2R.
No. 12.		Dyed with 12 kilos. Orchil Carmine, 1 kilo. Indigo Carmine, 50 grs. Naphthol Yellow.

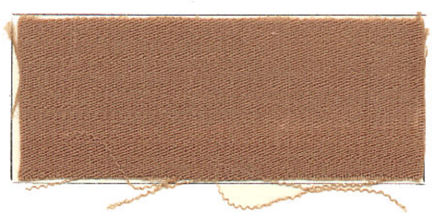
DYED SPECIMENS ILLUSTRATING TEXT, PLATE IV.

(WEIGHTS ARE FOR 100 LB. WOOL.)

No. 13.

Dyed with
200 grs. Patent Blue,
300 grs. Orange G.,
80 grs. Chromotrop R.

No. 14.



Dyed with
3 kilos. Orchil Carmine,
1 kilo. Indigo Carmine,
1½ kilos. Naphthol Yellow.

For these beautiful dyed patterns illustrating our text we are indebted to two eminent colour firms: Messrs. THE BADISCHE, Ludwigshafen, a/m Rhine, for Patterns No. 2, 3, 5 and 6 (silk); and to Meister LUCIUS & BRÜNING, Hoechst, a/m Maine, for Patterns No. 1, 4, 6 (wool) and 7 to 14.

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A Handbook for Oil Manufacturers, Refiners and Merchants, and the Oil and Fat Industry in General. By GEORGE H. HURST, F.C.S. Sixty-five Illustrations. 313 pp. 1896. Price 10s. 6d.; India and Colonies, 11s.; Other Countries, 12s.; strictly net, post free.

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