A METHODICAL VISUAL SYSTEM TO CREATE MATCHING INFILLS FOR MISSING AREAS IN WORKS OF ART ON PAPER BY DYEING COTTON RAG PAPERMAKING PULP DIFFERENT SHADES OF YELLOW, RED AND BLUE

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Background to the choice of colours

White light, daylight, passing through a slit and entering a prism is diffracted and emerges as a spectrum ranging from red to orange, yellow, green, blue and violet. If one colour is removed and the remaining colours are made to converge the result will be the complement of the colour removed. For instance, if violet is removed and the rest are made to converge, the result is yellow. Hence, using spectral colours, if any colour and its complement are mixed the result is white.

In the world of the artist and the paper conservator colours are not from diffracted light but are corporeal and are from pigments which operate by absorption of all other colours but their own. A blue object appears blue because only blue is reflected and all other colours are absorbed. In theory, if pure pigments existed that matched perfectly the colours of the spectrum and violet and yellow were mixed the result would be black. In reality it is grey.

In the range of colours from red to violet there are three primary colours: yellow, red and blue. Take any pair of complementary colours, for instance:

Red + green = red + (yellow and blue)
Blue + orange = blue + (yellow and red)
Yellow and violet = yellow + (red and blue)

It can be said that any colour contains yellow red and blue in certain proportions and of certain degrees of brilliance or certain depths of shade.

It is well known that if one stares at a solid block of red and then closes one's eyes green appears. It is as if the eye is offended and seeks to dispel the red by introducing green in order to produce a neutral colour, white or grey. This, perhaps, explains how the eye is able to look at a mixture of red and green pigments and see grey or to look at a mixture of red and yellow pigments and see orange. The offset lithographic process makes successful use of this condition.

Parameters for the development of a methodical system

Paper conservators, especially those who conserve art on paper, frequently require to infill missing areas of works of art. Present methods involve infilling with a sympathetic paper, a repair tissue or pulp, all of which usually have to be toned to match the surrounding colours of what may be termed The Host, the part of the primary support with the missing area.

This article's hypothesis is that the conservator can dye cotton rag paper pulp different shades of yellow, red or blue and, by putting pre-determined amounts of the dry dyed pulp in a blender with water, can create the colour desired to make such a match. For the research necessary to support or dispel this hypothesis it was decided to freeze all parameters involved other than the shades of each colour, yellow, red or blue. This article draws upon the findings of Ruth E. Norton's excellent paper entitled 'Dyeing Cellulose-fibre Paper with Fibre Reactive Dyes'.[1]

For the purposes of this paper it was decided to use exclusively the ICI Procion dyes and to follow the procedures set out by Norton.[2]

Background to Norton's dyeing method

The dyeing industry uses the term Depth of Shade, DOS. This is defined by the amount of dye required for each gramme of paper to be dyed. For instance, if 10g of cotton rag paper pulp were to be dyed to a DOS of 1% the amount of dye required would be 1% of 10g; 0.1 g of dye. Hence, 10g of paper to be dyed to a DOS of 4% requires 0.4g of dye. There are, therefore, no absolutes in the term DOS as to the colour or intensity of colour. It is merely what comes out when a certain amount of a dye is added to a certain amount of paper pulp.

Norton advises the use of two further constants in the dyeing of paper. The first is to use a standard concentration of dye powder in a stock solution of 1%w/v.[3] This means that for every gramme of dye powder required for a particular DOS, 100mL of the stock solution will provide it. The second is what is termed 'The Liquor Ratio'. This is the volume of the dye bath and is related to the weight of paper to be dyed.[4] The liquor ratio is 70:1 v/w. For each gramme of paper to be dyed the volume of the dye bath will be 70mL.

Divergence of the chosen method of dyeing from Norton's method

Norton makes stock solutions of the three colours. She establishes the depth of shade and the required final colour and calculates the amounts from each of the stock solutions. The three quantities of yellow, red and blue are added together and the sheet or sheets of paper are dyed to the required final colour. It was always the aim of this project to dye papermaking cotton rag pulp different shades of yellow, red and blue, and the first set of tests were carried out by dyeing sheets of this pulp. However, the core was always paler than the surface, and the resulting infill made from this material was paler than the surfaces, and so the DOS and repeatability were lost.

The final method followed is described in Appendix 1 but, in outline, it was to mix the dry pulp, the dye and the various chemicals in the blender. After each mixing process the result was left to soak for the periods recommended by Norton.[5] With accurate measurement of material, dye and chemicals repeatability was very accurate.

The construction of the colour charts

In order to test the hypothesis it was decided to create colour charts for the following depths of shade: $^1/_8$%, $^1/_4$%, $^1/_2$%, 1%, 2% and 4% (Figures 1, 2, 3, 4, 5 and 6). The colours were those used by Norton: Procion Golden Yellow MX-3R; Procion Scarlet MX-3G; Procion Navy MX-R.[6] Suppliers of these dyes pack them for themselves and call them by different names but the code after the name of the colour, for instance, MX-3R following Golden Yellow identifies the particular colour. It is important that at least the primary colour, red yellow or blue, is mentioned, since there are the same codes in each of these colours. Each swatch of each colour or hue would contain 10 parts; for example, 7 parts yellow, 2 parts red and 1 part blue. The first line of each chart would be a swatch of 10 parts yellow and, below, two swatches; one 9 parts yellow and 1 part red; the other, 9 parts yellow and 1 part blue. Each of the three colours on any single chart would be the same DOS. Furthermore, it was decided to dye, in each dyeing process, 5g of cotton rag paper pulp because this was the mid-capacity of the blender and this led, by calculation, to each swatch weighing 0.5g. Thus, for each chart the lines would be:

10 yellow (weight 0.5g)
9 yellow + 1 red (0.45g y + 0.05g r) 9 yellow + 1 blue (0.45g y + 0.05g b)
8y + 2r (0.40g y + 0.1g r) 8y + 1r + 1b (0.4g y + 0.05 g r + 0.05g b) 8y + 2b (0.40g r + 0.1 g b)
7y + 3r (0.35gy + 0.15g r) 7y + 2r +1b (0.35g y + 0.1g r + 0.05g b) 7y+1r+2b (0.35g y + 0.05g r + 0.1g b) 7y + 3b (0.35g r+ 0.15g b)

et cetera

It was believed that the colours of most interest to paper conservators would be those muddy ones that involve three colours and with a preponderance of yellow, and so each chart would need 10g of yellow, 5g red and 5g blue. These amounts were enough to complete the first six lines plus three of the seventh together with the 10R and 10B swatches.

The cotton rag paper pulp was dyed yellow, red or blue to the six depths of shade mentioned above by the dyeing process given in Appendix 1. The swatches for the six colour charts were made by the method set out in Appendix 2.

Comments on the processes and the results

1. Clumping

All who have carried out wet paper pulp infills are aware that the pulp tends to form itself into nodules or clumps. This tendency is much reduced if the ratio of the weight or volume of water holding the paper pulp in suspension to the dry weight of the paper pulp is in excess of 300:1. In making the swatches the combined dry weights of yellow, red and blue paper pulp was 0.5g. Hence the minimum volume of water used was 150g or 150mL. As the conservator applies the pulp he or she is looking for a thin suspension of pulp in water. This depletes the water or heightens the pulp/water ratio and so more water must be added to the mix as the work proceeds.

	yellow	red	blue
$^1/_8$%	line 1 minus	line 1	line 1 minus
$^1/_4$%	1 +	2	2 -
$^1/_2$%	2 -	3	3
1%	2 +	4	4 +
2%	3 +	5 -	6 +
4%	5 -	6 -	8
6%	5+		
8%	5.5		
10%	6 –		
20%	6+		

Table 1: *Matching of Depth of Shade of dyed pulp with Itten's Levels of Brilliance.*

2. The colour of the clumps

The clumps did not come from too little time in the blender because they were not yellow, red or blue but were the colour of the swatch finally produced. Hence, they must have been properly blended and then must have agglomerated later.

3. Repeatability of colour of the dyed pulp

In dyeing further batches of cotton rag paper pulp it was found that there was not always a perfect match between batches made at different times but variations were small and infrequent.

4. Grey

It will be seen that three swatches of the seventh line were made. The first is 4Y 3R 3B. This was made because it is possibly the last of those furthest away from the primary colours before the swatch becomes too purple. Its neighbours, however, (4Y 2R 4B and 4Y 1R 5B) were made because they are a reddish grey and a bluish grey, which may lead to black. Black in the Procion dyes is, in fact, dark blue.

Conclusion drawn from the first stage

Each colour chart has its own integrity. Each swatch on a chart can be seen to differ from its neighbours above, below and on each side in accordance with the theoretical amounts of yellow, red and blue which are supposed to be in the mix and so, with accurate weighing of materials and chemicals, the actual results do not stray much from the theoretical. Certainly, the hypothesis holds true for the lower percentages of DOS but the contrast between the different colours creates mottling which is discernible when the DOS is 1% or over.

An alternative to using colours of the same depth of shade to reduce mottling

In the remarkable treatise *The Elements of Colour* by Johannes Itten he argues "Equality of light or dark relates colours to each other. Light-dark contrast between them is extinguished." In order to clarify this problem of light-dark contrast he constructs a chart (Fig-

Level of brilliance	yellow	red	blue
3	2%	$^{1}/_{2}$%	$^{1}/_{2}$%
4	4%	2%	1%
5	8%	4%	1%

Table 2: *Regrouping of dyed samples showing Depth of Shade of each dye required to achieve certain Level of Brilliance.*

ure 9).[7] On the left hand side he arranges a grey scale, white at the top, black at the bottom and ten intervening shades of grey equally dispersed. In twelve vertical columns he arranges the colours of the colour circle, light at the top, dark at the bottom. The first column, adjacent to the grey scale, is violet; then the rest in this order: blue-violet, blue, blue-green, green, yellow-green, yellow, yellow orange, orange, red-orange, red, red-violet such that in each horizontal line all twelve colours of the colour circle are of equal Level of Brilliance. He locates the positions of the pure, saturated brilliance of each colour as follows: yellow is at the third line down, orange at the fifth, red at the sixth, blue at the eighth, violet at the ninth. He omits green but, by inspection, it is at the sixth. For any particular saturated colour he makes it paler by adding white and darker by adding black. If yellow, red and blue to depths of shade of $^{1}/_{8}$, $^{1}/_{4}$, $^{1}/_{2}$, 1, 2 and 4% are matched with levels of brilliance of the yellows, reds and blues of Itten's chart what emerges is shown in Table 1 (where a minus or plus or – or + appears it means that the DOS is just below or just above the level of brilliance.)

If the yellows, reds and blues are to be harmonised and contrast extinguished by making each of the three colours of the same level of brilliance the depths of shade should be grouped as shown in Table 2.

This can be plotted as a graph and the locus of the curve so generated is a parabola (Figure 10). By studying the graph it becomes clear that the depths of shade, $^{1}/_{8}$, $^{1}/_{4}$, $^{1}/_{2}$% are so close together, one level of brilliance apart at the most, coupled with their pale hues they merge naturally. But the higher depths of shade, 1, 2 and 4% span at least two levels of brilliance. Moreover, as the depth of shade climbs the increase in brilliance becomes less and less. The yellow cannot reach the seventh level of brilliance; nor the red the ninth; the blue, however, can easily pass the tenth by increasing the amount of dye powder. Of course Itten takes his saturated colour and adds white to make it paler and black to make it darker. This was not the chosen route in making the colour charts; depth of shade was the only variable. Colour charts for levels of brilliance 4 and 5 were made (Figures 7 and 8). Level of brilliance 4 has yellow DOS 4%, red DOS 2% and blue DOS 1%. Level of brilliance 5 has yellow DOS 8%, red DOS 4% and blue DOS 1%. Selection of these depths of shade was made from the graph (Figure 10) but, interestingly, there was variation from the graph because the colours seemed to merge better suggesting that there is work needed in identifying more accurately the tones of the different depths of shades used. In these latter two charts the blue becomes less dominant and the mottled effect is reduced.

To put the colour charts to use
It is assumed that the conservator who wishes to use the colour charts to make an infill in a missing area has to hand the colour charts, or the relevant parts of the colour charts; amounts of cotton rag paper pulp dyed yellow, red and blue of the DOS required; a blender; and a weighing machine that has graduations of 0.1g.

The edges of the missing area, or the host, are passed over the charts and the swatch that is nearest in colour to the host is identified. The conservator can decide that the host colour lies between two swatches; say between 6Y 2R 2B and 6Y 1R 3B. A new swatch of 6Y, 1$^{1}/_{2}$ R 2$^{1}/_{2}$ B can be made. It may turn out that the new swatch is too red and so another swatch is made with less red or with more blue and yellow. If the result is too dark undyed white cotton rag paper pulp can be added to lighten it. After a very few adjustments a colour match is achieved. If the missing area is small the amount of pulp already made may suffice; otherwise a calculation as to the quantity of pulp required has to be made. A first stab at this is possible by selecting an area of the undyed cotton rag paper pulp of a similar thickness, marking on it the missing area, cutting it out and weighing it. The proportions of yellow, red, blue, and possibly white, can be calculated, weighed and blended.

Appendix 1: The Process of Dyeing Cotton Rag Paper Pulp
Materials used in this process are as follows:
Procion Golden yellow MX-3R,
Procion Scarlet MX-3G,
Procion Navy MX-R,
Acid free cotton rag paper pulp made by Khadi Papers,
Sodium sulphate,
Sodium carbonate,
De-ionised water,
Tap water.

Sodium sulphate was chosen as a salt because Norton suggests that it may produce the best dye take-up. Both the sodium sulphate and the alkali, sodium carbonate, were manufactured by British Drug Houses and were of GPR quality. It is suggested that sodium chloride (table salt), Calgon and washing soda can be used but it was considered important that the process of dyeing of any colour, hue or density should be repeatable and so chemicals of known quality were used throughout.

For the reason given in the text of this article it was decided to standardise the amount of paper pulp in each dyeing process at 5g dry weight of cotton rag paper pulp.

In essence the process is: soak 5g of cotton rag pulp in the proper amounts of dye and salt, sodium sulphate, for 45 minutes; add the proper amount of alkali and leave to soak for 70 minutes for the three depths of shade less than 1%, or for 90 minutes for the three depths of shade of 1% and over; rinse. In fact, the ingredients, paper pulp, dye and salt were put into the blender and blended for 30 seconds, then decanted and left to soak for 45 minutes. They were then returned to the blender and the alkali added, blended for 30 seconds, left to soak for 70 or 90 minutes, then rinsed. The rinsing was done in a wooden-sided sieve of a fine mesh with running water until well

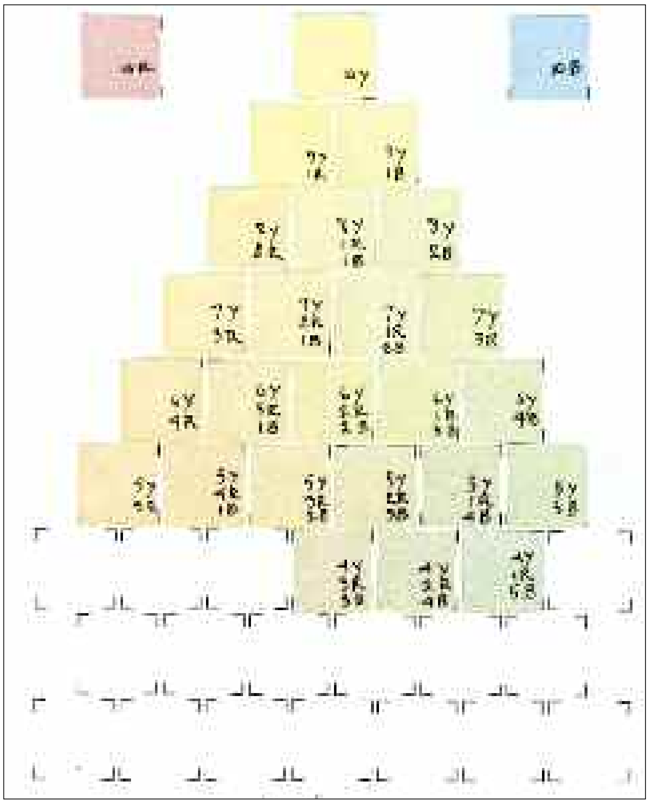

Figure 1. *Depth of Shade $^{1}/_{8}$% (0.125g dye to 100g dry pulp)*

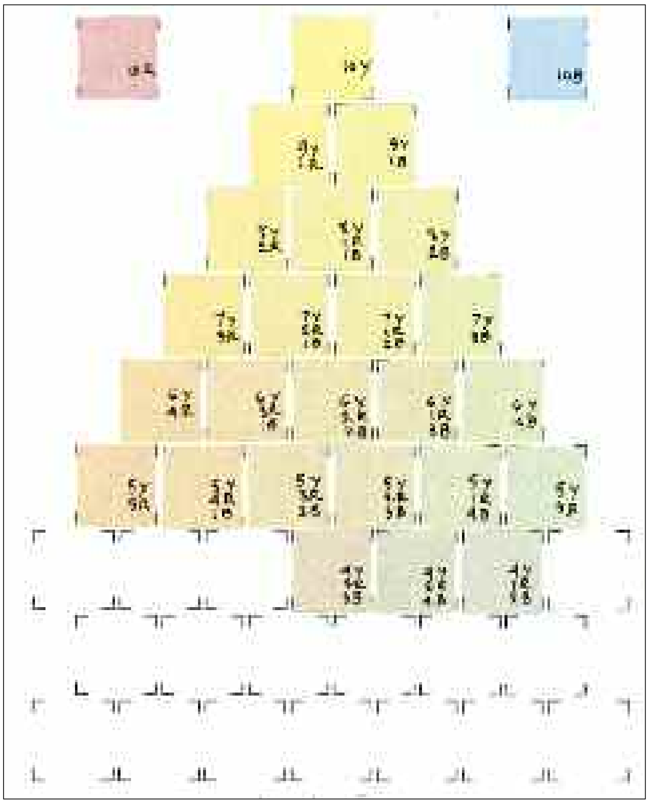

Figure 2. *Depth of Shade $^{1}/_{4}$% (0.25g dye to 100g dry pulp)*

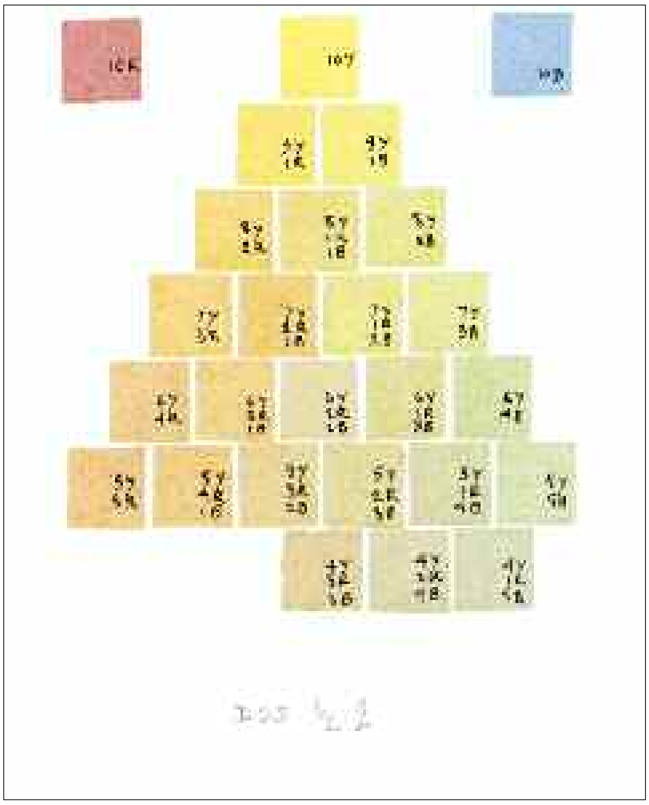

Figure 3. *Depth of Shade $^{1}/_{2}$% (0.5g dye to 100g dry pulp)*

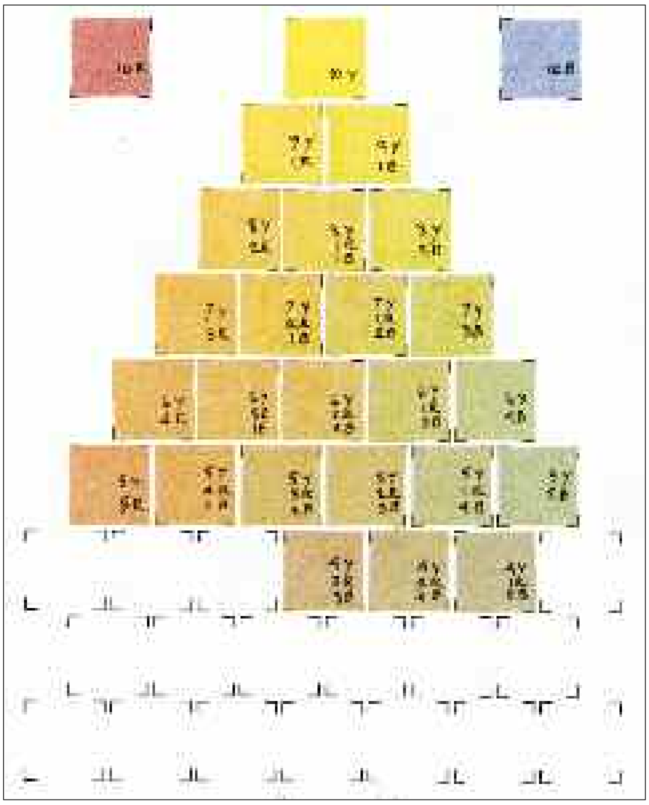

Figure 4. *Depth of Shade 1% (1g dye to 100g dry pulp)*

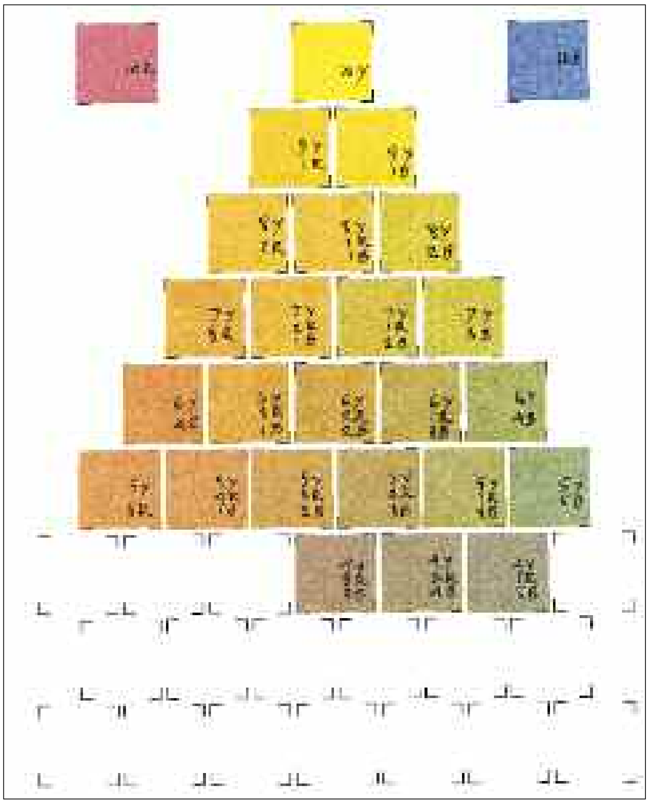

Figure 5. *Depth of Shade 2% (2g dye to 100g dry pulp)*

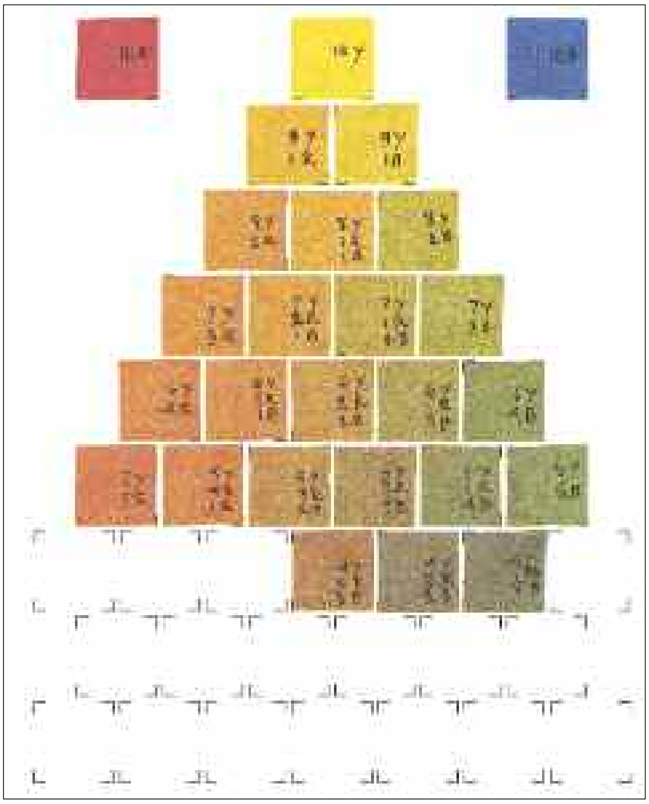

Figure 6. *Depth of Shade 4% (4g dye to 100g dry pulp)*

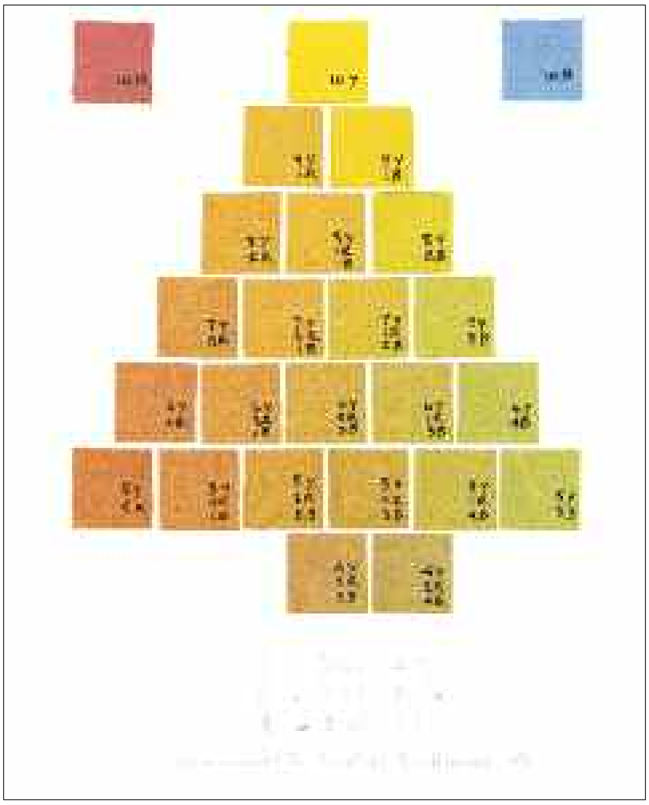

Figure 7. *Level of Brilliance 4, 4th level down on the colour chart, (figure 9). Each swatch contains the pure red, yellow and blue of the top line in the porportions hand written upon it.*

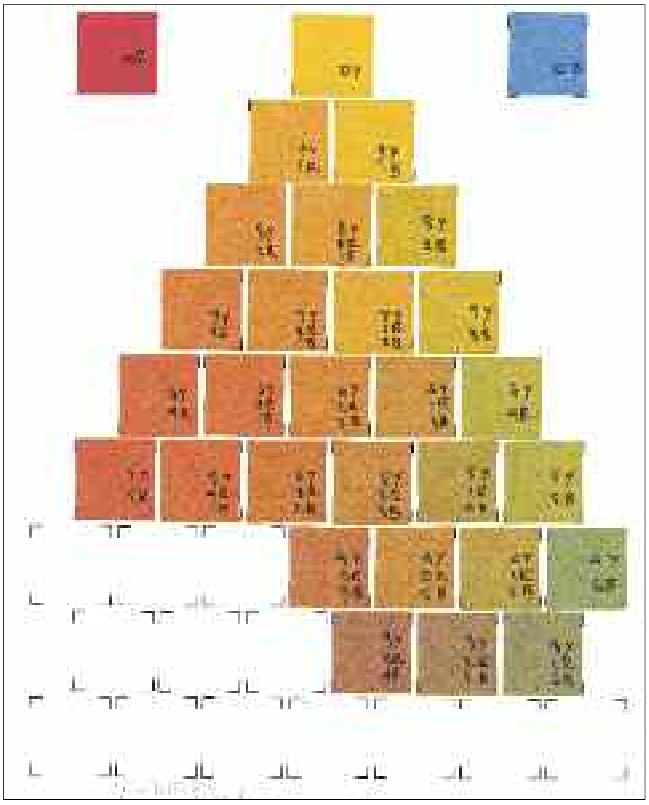

Figure 8. *Level of Brilliance 5, 5th level down on the colour chart (figure 9). Each swatch contains the pure red, yellow and blue of the top line in the proportions hand written upon it.*

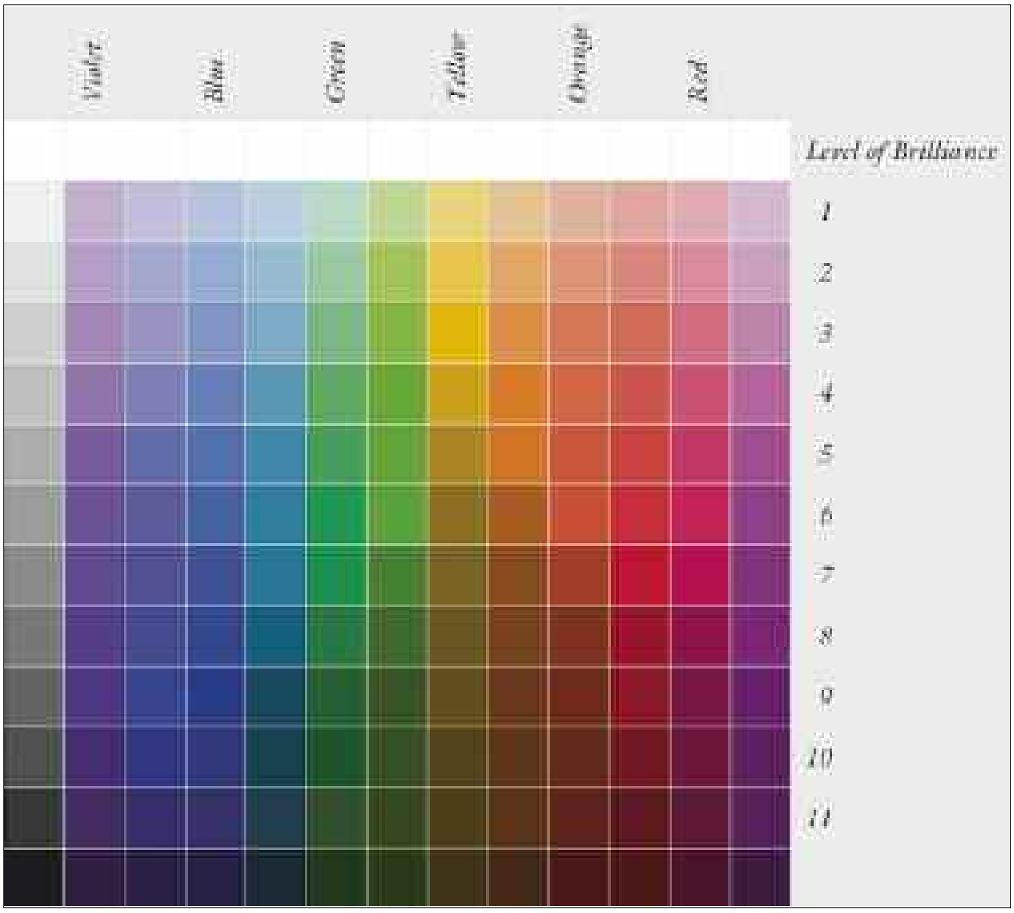

Figure 9. *Colour Chart. The left hand column has white at the top, Black at the bottom and 10 evenly graduated greys in between. To its right are the 12 colours of the Colour Circle, white at the top, black at the bottom such that each horizontal line has each colour of the same level of brilliance.*

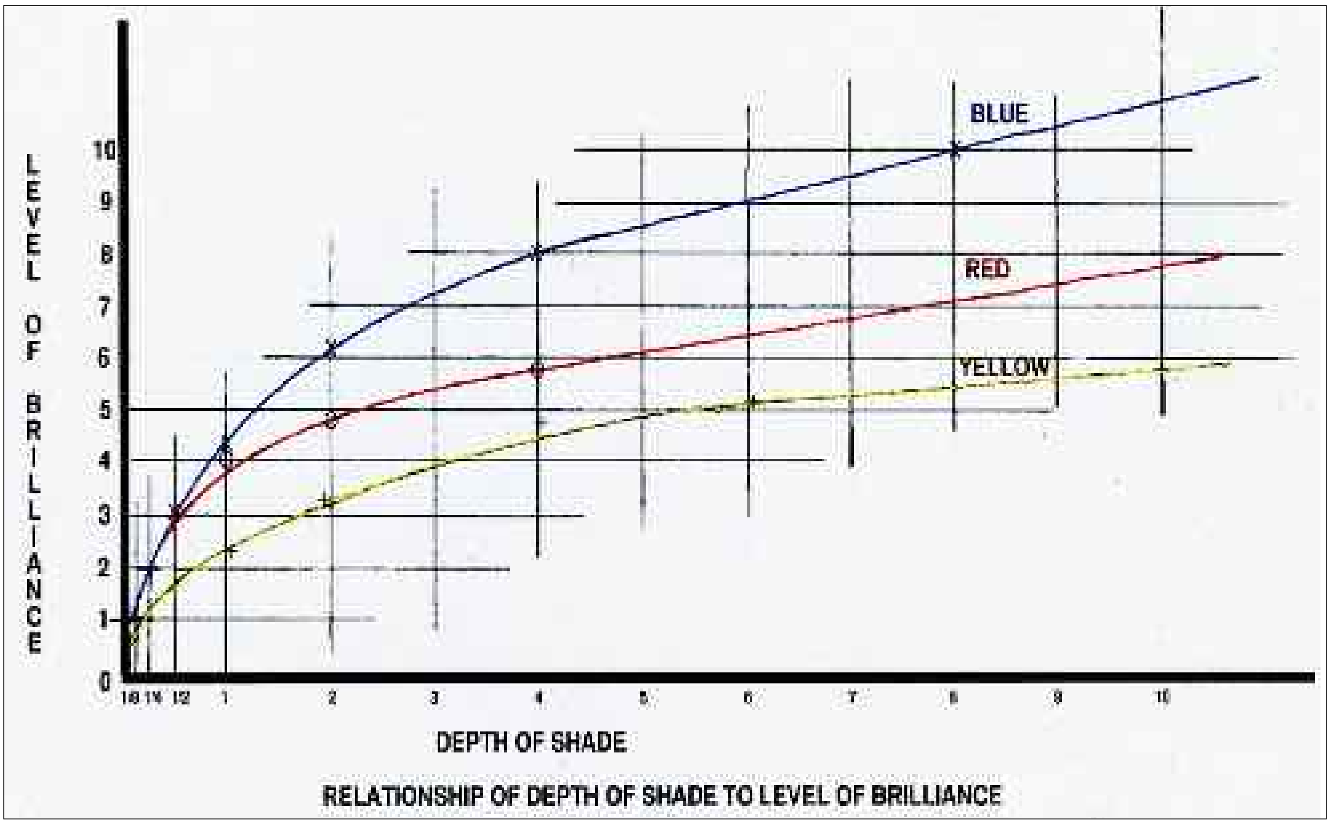

Figure 10. *The graphs plot, for yellow, red and blue, the relationship between the depths of shade (X axis) and levels of brilliance (Y axis)*

Figure 11: *Propaganda leaflet (appendix 3) recto before conservation.*

Figure 12: *Propaganda leaflet (appendix 3) recto after conservation.*

Figure 13: *Propaganda leaflet(appendix 3) verso before conservation.*

Figure 14: *Propaganda leaflet (appendix 3) verso after conservation.*

after the water ran clean. Water and pulp were spread out onto thick Bondina, the free water removed and the final product was left to dry.

50mL of dye stock solution was made by weighing 0.5g of dye and by weighing 50g of de-ionised water and adding the water to the dye. From the start it was decided to weigh the water for greater accuracy; this revealed just how inaccurate the calibrated jars and beakers can be. De-ionised water was used for the dye stock solution because Norton warns of colour change with tap water. Since London tap water has a pH of 7.9 to 8.0 it was considered safe to use it to dissolve both the salt, sodium sulphate, and the alkali, sodium carbonate. If this were to cause colour change it was considered that the variation would be less significant than those caused by small inaccuracies in weighing of the ingredients.

Table 3 below follows Norton's nomenclature, recommended weights and ratios, but the information is sometimes presented in a different way.

Wpaper = dry weight of cotton rag paper pulp = 5g
DOS = % of the weight of dye powder to weight of paper pulp
Cstock = concentration of dye used to dye paper pulp = 1% w/v dye powder/water
Vstock = vol of Cstock to achieve chosen DOS = DOS X Wpaper / Cstock
Vbath = Wpaper X Liquor Ratio R. R for paper pulp is 70:1 = 70 X 5g = 350mL
Wsalt = 50g/L of dye bath = 50g X 350/1000 = 17.5g
Walk = 20g/L of dye bath = 20g X 350/1000 = 7g
Valk = vol of water to dissolve Walk = Vbath /4 = 350/4 = 87.5mL.[8]
Vsalt = vol of water to dissolve Wsalt = Vbath - Valk – Vstock or Vbath = Vsalt + Valk + Vstock

To the process, for example $^1/_2$% DOS yellow:
Weigh 0.5g yellow dye
Weigh 50g de-ionised water
Add water to dye to create dye stock solution
Weigh 5g dry cotton rag paper pulp. Tear into small pieces and put into blender
Weigh 17.5g sodium sulphate and dilute in 260.0 mL of hot tap water; put solution in blender
Weigh 2.5g yellow dye stock solution and pour into blender
Blend mix for 30 seconds
Pour mix into a jar and let stand for 45 minutes
Weigh 7.0g sodium carbonate and dissolve in 87.5mL hot tap water, pour into blender
Add mix that stood for 45 minutes to blender
Blend all for 30 seconds
Pour all into a jar and let stand for 70 minutes
Pour all into a sieve and rinse with tap water until the

water runs clean for some time
Remove free water and allow dyed pulp to dry.

The removal of free water can be done by pouring the final mix onto thick Bondina on the vacuum table, covering it with a non-porous sheet, rubber, plastic and turning on the vacuum; or by squeezing between two pieces of thick Bondina but care must be taken that pulp does not run away as water flows out.

Appendix 2: Making Swatches
For reasons explained in the text of this article it was decided that, for each swatch, there would be a total of 10 parts, each weighing 0.05g, of the three colours yellow, red or blue. For the process the swatch maker had to hand:

thick Melinex,
thick and thin Bondina,
blender,
balance capable of weighing accurately 0.1g
vacuum table
hair dryer.

A square of 25mm X 25mm was cut from the middle of a piece of thick Melinex of overall dimensions 150mm X 100mm. The Melinex was placed on the vacuum table and beneath the open rectangle was a piece of thick Bondina which was slightly bigger than the 25mm X 25mm square and which was on the vacuum surface. It was covered by a piece of thin Bondina, matt side uppermost, and bigger than the thick Bondina. The rest of the vacuum surface was blanked off. Let us use the case of making the swatch 4 yellow, 3 red and 3 blue. The balance was set to 0.2g and small pieces of dry yellow cotton rag pulp were put onto the tray until the correct weight was arrived at. The balance was adjusted to weigh a further 0.15g and small pieces of red pulp were added to the tray until the correct weight, 0.35g, was achieved. The balance was further adjusted by 0.15g and blue was added to the tray until the correct weight, 0.5g, was arrived at. On the tray was 0.2g yellow, 0.15g red and 0.15g blue. If multiplied by 2 this gave us 4 parts yellow, 3 parts red, 3 parts blue; each part weighing 0.05g totalling 0.5g. The dry pulp was put into the blender and something over 150mL of tap water was added giving a ratio of pulp to water of over 1: 300. This was blended for 30 seconds and was decanted into a beaker (clear plastic picnic cups were used). This was left to settle for a few minutes until a layer of clear water was visible above the suspended pulp. The vacuum was switched on and, with a dropper, the suspended pulp put into the rectangle until the pulp was visibly higher than the upper surface of the thick Melinex and pulp overlapped the edges of the rectangle. Another piece of thick Melinex was placed over pulp and the swatch was boned flat. The swatch was dried with the hair dryer with the vacuum still on. The vacuum was turned off and the thick Melinex with swatch and the 2 Bondinas beneath was lifted from the vacuum surface and any water on the underside of the thick Melinex was dried. The thick Bondina came away easily but care was taken to peel off the thin Bondina because it tends to stick to the swatch. It was found that the matt side of the thin Bondina was less likely to stick. The swatch was pressed out of the Melinex, the edges were trimmed and '4Y 3R 3B' was written on the flat surface before being put into its place on the colour chart.

Appendix 3: The Conservation of A Propaganda Leaflet in Polish
In 1941 during the Second World War leaflets such as this (Figures 11-14) were packed into a German rocket, the Propagandagranate, which was launched on a trajectory over Poland. At a set time after launch a small bursting charge was ignited within the rocket which blew open a flap and the leaflets were scattered and left to fall to the ground. In the light of this it was decided that the burns and scorches were part of the leaflet's story and should be retained. For the sake of clarity the dark red side of the leaflet is named the recto and the Union Jack side the verso. Since the leaflet is of an archival nature it was decided that infills should be visible but should not distract the eye. Further, it was decided that the pale grey edges to the tears and missing areas should not be disguised. The primary support though thin is in surprisingly good condition.

The repairs, visible on the recto, were made with Tengujo and starch paste to hold tears together while relaxing and pressing the pamphlet to permit infilling to take place. Once the infilling was complete they were removed and replaced on the verso.

The aim, in compiling the colour charts, was to encompass the colours and shades most used to infill missing areas. It was presumed that the paler shades of the muddy hues that use all three colours, yellow, red and blue, tending towards yellow, the orange browns, the colours of degraded white paper. The charts, therefore, omit the colours that approach purple, pure red and pure blue. As is the way with these things the project that comes into the studio which is suitable to demonstrate dyed pulp infilling has colours that are outside the charts' range. It was necessary to dye pulp especially for this project as follows; red 8% DOS, yellow 6% DOS, red 10% DOS, yellow 20% DOS.

As to making pulp to match the reds of the recto, the first

DOS	Vstock	Valk	Vsalt	Vbath	Wsalt	Walk
$^1/_8$%	0.625mL	87.5mL	261.875mL	350.0mL	17.5g	7.0g
$^1/_4$%	1.25	87.5	261.25	350	17.5	7
$^1/_2$%	2.5	87.5	260	350	17.5	7
1%	5	87.5	257.5	350	17.5	7
2%	10	87.5	252.5	350	17.5	7
4%	20	87.5	242.5	350	17.5	7

Table 3: *Addition levels of different additives required to achieve dyed samples with particular Depth of Shade.*

guess was Swatch 1, 8 parts red 8% DOS plus 2 parts blue 1% DOS. The second, swatch 2, 5.2 parts red 10% DOS, 2.4 parts yellow 20% DOS, 2.4 parts blue 2% DOS. In Figure 11, swatch 1 can be seen in the lower left hand portion of the leaflet's recto above 'Wtoch' and to the left of 'Iran'. Swatch 2 can be seen in the upper right hand portion to the right of 'TWEC' and above 'zyczeniem'. Each swatch matches well the colour on which it rests. However, each swatch was too orange for the areas to be infilled. Swatch 3; 4.9 parts red 10% DOS, 2.2 parts yellow 20% DOS, 2.9 parts blue 2% DOS. Combinations of swatches 2 and 3 were used to infill the recto. These colours, red 10% DOS, yellow 20% DOS and blue 2% DOS are all within the region of Level of Brilliance 7 on the graph Figure 10. It is surprising how well they blend together so lending credence to Itten's pronouncement on merging colours.

Regarding the pulp mixes for the verso (Figure 13); the red was the result of mixing 8 parts of swatch 1 with 2 parts of white, undyed pulp. The white comes from 4 parts yellow, 3 parts red, 3 parts blue of the $^{1}/_{2}$% DOS chart with small additions of yellow and red. The blue comes from 4 parts yellow, 3 parts red, 3 parts blue of the 2% DOS chart plus a small addition of blue. These colours lie between Levels of Brilliance 3 and 6 on the graph (Figure 10) and mottling can be seen in the blue infills of the verso (Figure 13).

In carrying out the tests for the foregoing study it was necessary to retain the swatches for the various mixes in order to observe the progression from the colour selected from one of the charts to that finally used. In real life, however, matters are simplified if the intermediate swatches are returned to the mix so that the conservator retains the amounts of the original mix from the chart. It becomes harder to judge when the original ingredients diminish as additions are made.

For each infill its shape plus 2mm all round was cut from thin plastic sheet or from thin Melinex. This mask was laid on the vacuum table (the vacuum surface was a medium density sintered polyethylene) and the rest of the vacuum surface was blanked off. The edges of the missing area of the leaflet, recto down, were aligned with the area cut out. The light box and the vacuum were switched on. The pulp suspended in water was dispensed by a nasal decongester for the larger areas and a 3mL plastic pipette with the thin, nozzle end cut off just before the first increase in its diameter. Both were held as horizontal as possible to minimise the danger of clumps forming. The bulb is squeezed and the pulp lands on the vacuum surface and the water in taken away; the higher the level of the vacuum, the greater the degree of control over the water wetting the edges of the host. When the right thickness of the infill is arrived at a piece of thick Melinex is placed over it and is burnished with a bone folder to flatten the upper surface and to drive more water out. A hair dryer is held over the infill until it is dry. The vacuum is turned off and the object and infill are freed by inserting a thin palette knife between the underside of the infill and the vacuum surface.

The three areas of pressure sensitive tape adhesive along the bottom edge of the object (Figures 11 and 13) were removed on vacuum using alternately acetone and toluene. The results of the treatments can be seen in Figures 12 and 14.

Notes and References

1. Norton, R.E., 'Dyeing Cellulose-fibre Paper with Fibre Reactive Dyes', *The Paper Conservator* 26 (2002) pp.37–48.
2. Norton, Ref 1, Appendix 2, pp.44–46.
3. Norton, Ref 1, Appendix 2, paragraph 3.
4. Norton, Ref 1, Appendix 2, paragraph 6.
5. Norton, Ref 1, Appendix 2, p.45, 'Procedure', notes 5 and 6.
6. Norton, Ref 1, Appendix 2, p.44, 'Materials' note 4, dye.
7. Itten, J., *The Elements of Colour* (Ravensburg, Germany: Ravensburger Buchverlag Otto Maier GmbH, 1961) p.43.
8. Norton, Ref 1, pp.37-48.