SENATE HOUSE
London WC1

A Report on the Decorative Schemes
following an Examination of the
Malet Street Railings

Patrick Baty

7th October 2016

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A BRIEF SYNOPSIS

It appears that the railings have not been painted for about fourteen years.

Nonetheless, the ironwork has been painted on fifteen occasions since 1932 (although elements at the north end of Malet Street display only fourteen schemes, which accords with their having been erected in 1934).

Grey has always been employed, and the full gamut of that colour has been used, from dark greenish greys to lighter bluish grey and even a couple of noticeably pinkish greys. Until about 2002 they were painted on a fairly regular basis, even allowing for the interruption of the War.

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Introduction

I was instructed by Mr Duncan Clough, Senior Project Manager at the University of London, to carry out an investigation of the paint on the Malet Street frontage railings.

Location

Senate House is the administrative centre of the University of London, situated in the heart of Bloomsbury, London between the School of Oriental and African Studies to the north, and the British Museum to the south.

Historical Background[1]

After the First World War the University of London, then based at the Imperial Institute in Kensington was in urgent need of new office and teaching space to allow for its growth and expansion. In 1921, the government bought 11 acres (4.5 ha) of land in Bloomsbury from the Duke of Bedford to provide a new site for the University. However, many within the university were opposed to a move, and, in 1926, the Duke bought back the land. The election of William Beveridge however to the post of Vice-Chancellor of the University in June 1926 was highly significant as Beveridge supported a move to Bloomsbury. Beveridge persuaded the Rockefeller Foundation to donate £400,000 to the University and the original site was reacquired in 1927.

Beveridge saw the university as one "for the nation and the world, drawing from overseas as many students as Oxford and Cambridge and all the other English universities together." and specified that "the central symbol of the University on the Bloomsbury site can not fittingly look like an imitation of any other University, it must not be a replica from the Middle Ages. It should be something that could not have been built by any earlier generation than this, and can only be at home in London ... (the building) means a chance to enrich London – to give London at its heart not just more streets and shops ... but a great architectural feature ... an academic island in swirling tides of traffic, a world of learning in a world of affairs."

[1] Taken almost verbatim from Wikipedia.

The grand art deco design was the work of Charles Holden, who was appointed as architect in March 1931 from a short list which also included Giles Gilbert Scott, Percy Scott Worthington and Arnold Dunbar Smith. In making their choice, Beveridge and the Principal, Edwin Deller, were influenced by the success of Holden's recently completed 55 Broadway, designed as the headquarters for the London Electric Railway and then the tallest office building in London.

Holden's original plan for the university building was for a single structure covering the whole site, stretching almost 1,200 feet (370 m) from Montague Place to Torrington Street. It comprised a central spine linked by a series of wings to the perimeter façade and enclosing a series of courtyards. The scheme was to be topped by two towers; the taller Senate House and a smaller one to the north. The design featured elevations of load-bearing brick work faced with Portland stone. Construction began in 1932 and was undertaken by Holland, Hannen & Cubitts. King George V laid the ceremonial foundation stone on 26 June 1933 and the first staff moved in during 1936, the University's centenary year. Due to a lack of funds, the full design was gradually cut back, and only the Senate House and Library were completed in 1937, although the external flanking wings of the north-eastern courtyard were not constructed. As he had with his earlier buildings, Holden also prepared the designs for the individual elements of the interior design. The completion of the buildings for the Institute of Education and the School of Oriental Studies followed, but the onset of the Second World War prevented any further progress on the full scheme.

The railings were designed by Charles Holden and the wrought iron was made by H.H. Martin & Co Ltd, of Cheltenham, in about 1932.

Areas Examined

Samples were taken from each of the ironwork elements on the front of the building. A list of samples, photographs and drawings can be seen in the appendices.

Scope of Report

The purpose of the paint analysis was to establish the sequence of decoration.

Investigation of Samples

A total of 20 samples were taken by Patrick Baty on 26th September 2016.

This report contains the following:
a) Appendix One – Elevation and photographs of some of the elements sampled;
b) Appendix Two - Photomicrographs of relevant cross-sections;
c) Appendix Three - A list of the samples taken;
d) Appendix Four - Some pigments mentioned in the text;

e) Appendix Five – Some information on the analysis techniques, and
f) Bibliography.

Limitations

Occasionally in this report an effort has been made to suggest possible dates for a number of the schemes found during analysis. It is believed that to provide some sort of context for the sequence of paint layers will be of more use than to offer no suggestion at all. Where dates have been proposed they may have been based on a number of factors:

a) The position of a particular layer in relation to known events;
b) The occurrence of pigments with a known date of introduction;
c) The position of a scheme in the sequence of coatings applied to a surface (i.e. those applied first will be earlier than those at the top). Often, by dividing the age of a surface by the number of schemes applied to it, an approximate repainting cycle[2] can be obtained;

Any dates given are indicative only, and there will be instances where these may be amiss by 10 years or so.

Some Notes on Terminology

The following term appear throughout the report.

Scheme A series of coats of paints usually applied within days of each other when (re)decoration is carried out. A scheme in oil paint may consist of a primer (initially), one or two undercoats and a top / finish coat.

White A paint made up of a white pigment such as chalk, or lead white, with no visible colouring matter (pigment) added. The overall effect would often have been of an off-white due to the inherent yellowness of the pigment and / or the medium.

Off-White A paint consisting of a white pigment such as chalk, or lead white, with small amounts of visible colouring matter (pigment) added. Sometimes, however, a very small quantity of blue or black was added to a white paint to make it appear "whiter" (i.e. to appear white). It is sometimes difficult to judge when pigment was added to correct the inherent yellowness of some paints or to impart a slight tint. At the other end of the scale the difference between an off-white and a pale stone colour is minimal and, as a result, inconsistencies in description are likely to occur.

[2] Although only intended as a rough guide to the dating of layers, this simple device of dividing the age of the building by the number of schemes usually provides worthwhile information. This technique has been written about in American technical publications (e.g. Doonan 1982, 27-29) but has also been dismissed as being unscientific by another writer (Welsh 1986, 4-5).

Stone Colour A variety of colours ranging from off-whites to quite dark shades. Designed (broadly) to resemble the colour of stone in its many forms (e.g. Bath stone or Portland stone). The difference between a pale stone colour and an off-white is minimal and, as a result, inconsistencies in description are likely to occur.

In Appendix Two there are three chemical symbols used:

TiO_2 = Titanium Dioxide
ZnO = Zinc Oxide
Pb = Lead

It is very difficult to interpret the depth of a colour when viewed as a cross-section under the microscope. The large amount of light used to illuminate the sample combined with the magnified detail causes distortion. The only way of getting a closer idea of the depth of colour is to remove a small lump of the substrate, to carefully expose the relevant layer and to leave it exposed to UV light for a period of time. This is not always practical, especially when sampling a room in an inhabited building or ironwork (where the substrate is not removed). For that reason, a general description of the colour is given. By definition this may sometimes be misleading. The rule of thumb is that colours are invariably darker than they appear in a photomicrograph.[3] If anything, the descriptions of the colours in this report are likely to err on the paler side.

Thoughts on Dating

The railings and gates seem to have been painted on fifteen occasions, although those at the north end have one fewer scheme. This fits in with the belief that the railings were completed at the north end two years later than those at the south end.

If one assumes that the southern railings were first painted in about 1932, when they were made, and last painted in about 2002[4] this means that they have been painted over a period of 70 years. If one now divides that by the number of schemes it can be seen that the repainting cycle was roughly 4.6 years. With this sort of information, it is possible to give a rough date for each of the schemes and, therefore, to indicate when there were significant changes of colour.

However, this calculation is overly simplistic because it does not take into account the interval between schemes during the period of the Second World War, when paint was rationed and only essential maintenance carried out,[5] this will affect the figure slightly. Nor does it take into account the apparent repaint of the original railings and gates, two years after erection, when the north end

[3] (Baty 1995:2, 27-37) (http://bit.ly/v5zhF). (Baty 1996, 9-15) (http://bit.ly/10s8kc).
[4] Ex info Duncan Clough.
[5] Building Controls were only removed in October 1954, although the number of schemes here suggests that maintenance was continued more often over the 1939-1954 period than is seen elsewhere. Usually one encounters strong evidence of the War years when examining external paintwork in London. This is in the form of a thick layer of dirt and some weathering. None was observed on the samples from the Senate House railings.

was completed. No matter, it allows us to compare the repainting cycle with that found on other railings and gates, and one does this in order to ensure that the railings had not been stripped at any time. Experience gained elsewhere suggests that a repainting cycle nearer to 6 years is more usual, although on some London estates, where more frequent redecoration is / was specified, this cycle may be reduced to just under five years.[6]

Given the above it can be seen that the railings and gates have not been stripped and that they were repainted on a regular basis until the last occasion.

Analysis of Samples

General

Grey has always been employed, and the full gamut of that colour has been used, from dark greenish greys to lighter bluish grey and even a couple of noticeably pinkish greys. Until about 2002 they were painted on a fairly regular basis, even allowing for the interruption of the War.

From information provided by Duncan Clough, it appears that the railings have been painted light grey for twenty years or more and that they have not been painted for about fourteen.

Sampling ironwork can be difficult, depending upon its size and shape and it is rare that one can remove a fragment of metal with the paint. Some of the samples show a layer of rust at the base of the sequence and the evidence on one suggests that the ironwork might have been dipped in hot boiled linseed oil at the foundry (see SHR/19 in Appendix Two).

Detailed Analysis

A sample taken from the low guard rail set into the top of the wall around the SW corner of the building (Malet Street and Montague Place)[7] displays just one decorative scheme. The fixings and paint suggest that this is a fairly recent introduction (see photomicrograph of SHR/1).

The decorative nature of the piers with the circle and diamond detail might be an indication that the latter had been picked out in a different colour to the body of the piers. As a consequence, samples were taken from each element on several of the piers – both from those framing gates and those supporting panels. When one compares the samples from the gate at the south end, for example – SHR/5 from the pier; SHR/3 from a diamond and SHR/4 from a circle – it can be seen that there was no colour difference at either the beginning or at any later stage. It can also be seen that there are fifteen schemes on each of these surfaces.

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[6] Various railings in London that illustrate this are as follows: The Foreign and Commonwealth Office - 6 years (Baty 1995:1, passim); Royal Hospital (Baty 2004, 4) - 5.9 years the Benjamin Franklin House, Craven Street – 5.8 years (Baty 1998:2, 10); and Home House, Portman Square (Baty 1998:1, 5) and 6 Fitzroy Square (Baty 1995:3, passim) – both 4.8 years.

[7] See Appendix One for a photograph.

However, when one compares SHR/6, from an upright close to the south end, with SHR/19 from an upright from the north end (between the main gates and the pedestrian gate) it can be seen that there is one less scheme at the north end.[8] Furthermore, the second scheme at the south end is the same as the first at the north end and each starts with a very distinctive coat of red lead paint. This suggests that the first of the fifteen schemes at the south end dates from 1932 and that the second dates from 1934.[9]

When one then looks closely at the first scheme it can be seen to be a darkish grey with a slightly green undertone. Three coats of paint were applied to the railings (see SHR/6). At the base of this cross section can be seen some evidence of rust and then a mid-grey primer. A mid-grey undercoat was then applied after which came a darker and greener top coat. A thin layer of dirt can be seen on its upper face.[10] This scheme seems to have been based on lead white.[11] It is thought that the colour could have come from the very first British Standard paint range[12] and may originally have been No. 34 Slate.[13]

A primer consisting of red and white lead was applied as the first of the coats that formed the second scheme.[14] This can be seen in most of the samples as a bright orange layer (see SHR/3 and SHR/6 for example). A mid grey undercoat and a slightly darker and greener top coat followed. A red lead primer can be seen at the bottom of the sequence of coatings on an upright from the north end (see SHR/19) which, as has been explained, was applied when the second scheme was applied at the south end. Underneath this are particles of rust and, presumably applied directly to the metalwork, the remains of what appears to be a coat of oil.[15]

The top coats of the third and fifth schemes were very similar to the first two, but the fourth one has a distinctly greyish green appearance.[16] In some of the cross sections this fourth scheme displays small amounts of the pigment chrome yellow (see SHR/3 for example).[17] It is just

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[8] See photographs of these elements in Appendix One.
[9] Dates reported by Duncan Clough.
[10] Until the introduction of the Clean Air Act in 1956 samples taken from the exterior of London buildings invariably show a thin film of dirt.
[11] Until the second half of the twentieth century the main constituent of most architectural paints was lead carbonate, a white compound derived from metallic lead. Throughout this report it is referred to as "lead white". See Appendix Four for some information on this.
[12] Following moves made in the paint industry in the early years of the twentieth century the first range of standardised paint colours was published in 1930. A British Standard, BS 381, which (with additions in 1931) became BS 381C: 1931 Colours for Ready Mixed Paints formed the greater part of the limited palette of paint colours available from most paint manufacturers throughout the next twenty years.
[13] BS381: 1930. Schedule of Colours for Ready-Mixed Paints. This colour was retained in later issues of that BS range as BS381C 634. Although not identical, the nearest other modern Standard is RAL 7039 Quartz Grey.
[14] Some samples show a fairly pure red lead paint (SHR/19) while others show a small amount of lead white added (SHR/4). Red lead dried very quickly. See Appendix Four for some information on the pigment.
[15] Although 45 years earlier a coat of boiled oil had been found as the first layer on the ironwork of Hammersmith Bridge, when that was examined a few years ago, and was a common method of resisting rust, which would otherwise have started to corrode almost immediately (UCL 1989, passim). Such a treatment was also found in the contract documents for Tower Bridge during its analysis (Baty 2009, 6).
[16] The third scheme appears to have been composed of a blend of lead white and zinc oxide.
[17] See Appendix Four for some information on this pigment.

possible that the colour was broadly similar to the other early ones, but had been supplied by a different manufacturer.[18]

The sixth scheme is the first of the paints of a distinctly 'modern' appearance to be applied. It was a paler bluish grey that appears to have been based primarily on lead white, but with a high zinc content.[19] This is marked in most of the photomicrographs in Appendix Two. Although there is no information to confirm it, it seems possible that it dates from the mid-1950s.[20]

Most of the subsequent schemes have been grey, but of different types, and applied over undercoats of grey, stone colour and off-white. Indeed, the eighth and ninth schemes were very warm greys, almost pinkish.

The tenth scheme is very clear in all the cross sections and was as dark and green as the early ones. It was also the first scheme to have been based on titanium dioxide.[21] Once again, this is marked in most of the photomicrographs in Appendix Two. However, lighter tones were adopted on the remaining five occasions.

Until the 1950s the overwhelming majority of the paints applied were based on lead white. An occasional inclusion of zinc oxide can be seen. At first the two were blended and as zinc oxide began to be accepted by the (normally conservative) house-painter one often finds a higher proportions of zinc being added to exterior paints. The more recent schemes have been based substantially on titanium dioxide. The paints would all have had a mid- to high level of sheen.

Recommendations

There is no doubt that the railings have been painted in variations of grey since the 1930s. Originally the colour was darker than it is now and would, perhaps, have stood out more against the newly-cut Portland stone. From that point of view, especially now that the stone has darkened, there might be a logic in returning to a darker shade. However, probably for the last 35 years or so – about half of its existence - the tone has been much as it is now. It is a subjective matter, clearly, but the present tonality works well against the stone backdrop. It does not distract from the architecture and is suitably understated. The adoption of the darker grey or, perish the thought, black, would act as an interruption and upset the visual balance.

[18] One might have thought that the specification of a British Standard colour (if that is what they were) would ensure an exact match. However, there has always been a certain amount of leeway as different manufacturers interpret the Standard in a different way.
[19] See Appendix Four for some information on this pigment.
[20] This statement is based on the position in the sequence of decorative schemes and its appearance.
[21] See Appendix Four for some information on this pigment.

An Aside on Black

In spite of a widely-held theory that black was introduced on railings as a mark of respect to Prince Albert, who died in 1861, there is no substance to this either here or on any other site that has been examined. The first general use of black is rather more prosaic, for until the gradual introduction of alkyd resins after the War black paints tended to be slow-drying – not a good idea when painting external elements.[22]

Although alkyd resins first appeared in the 1930s the War interrupted their development and they only began to replace the earlier lead-based paints in the years after the relaxation of Building Controls in 1954. Another great advantage of black, which encouraged its rapid take-up, was that it helped with achieving uniformity in a terrace of buildings.[23] This however is a discrete entity and there is no reason to fit in with neighbouring buildings.

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[22] Lamp black, the main constituent of black paint, is a very slow-drying pigment (see Appendix Four). This is discussed in an article written for the Chelsea Society Journal and posted here http://patrickbaty.co.uk/2010/10/20/the-colour-of-chelsea/ If this theory had any validity one might have expected black to have been applied on a site so close to the Albert Memorial as Albert Hall Mansions – it was not. Red oxide was found on the first six schemes (Baty 2012, passim). However, there are the odd exceptions and one does occasionally see an early use of black on external ironwork.

[23] From analysis of all the railings in Charlotte Square, Edinburgh, this would appear to be from about 1953 (Baty 2000, 4). Analysis of railings in London - on 20 Portman Square, and 6 Fitzroy Square - has indicated that black was first used ca.1955 (Baty 1998:1, 7) & (Baty 1995:3, 1). At 88 Sloane Street it appears to have been ca.1958 (Baty 2016, 9).

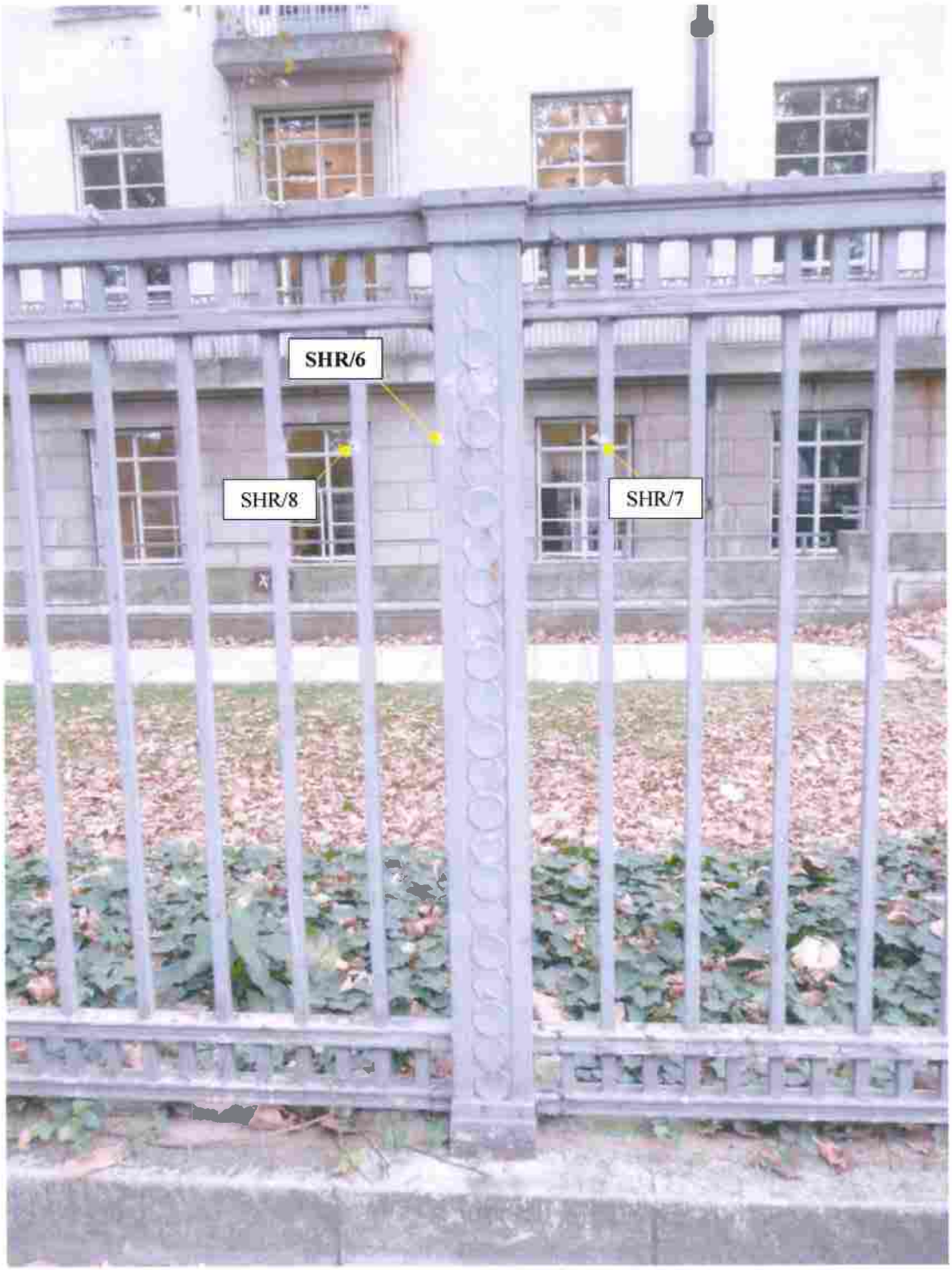
APPENDIX ONE

PHOTOGRAPHS AND LOCATION OF SAMPLING

(Samples shown in **bold** are illustrated in Appendix Two)

Low Guard Rail on SW corner of the building (Malet Street and Montague Place)
(see sample SHR/1 in Appendix Two)

Gate Pier SW Corner. Note the Decorative Detail
(see samples SHR/3; SHR/4 and SHR/5 in Appendix Two)



4th Decorative Pier from SW Corner
(see sample SHR/6 in Appendix Two)

N end. Main gates. Upright of panel between R/H main gates & R/H pedestrian gate
See sample SHR/19 in Appendix Two)

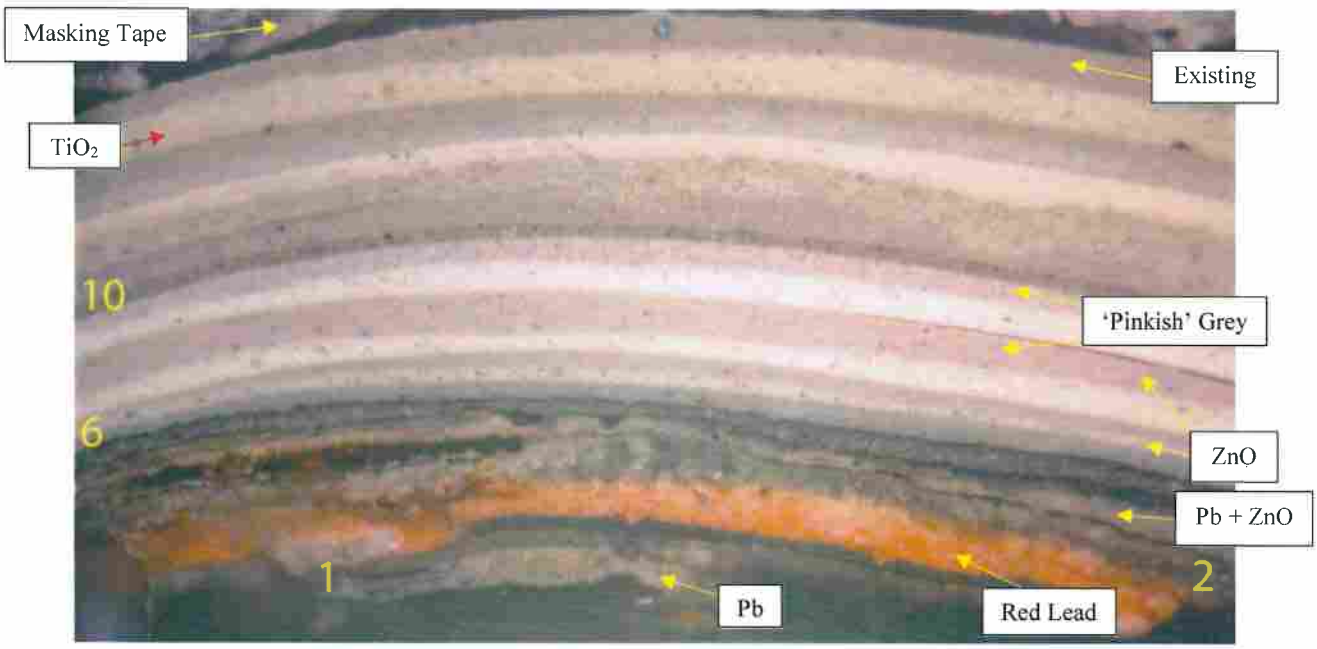
APPENDIX TWO

PHOTOMICROGRAPHS

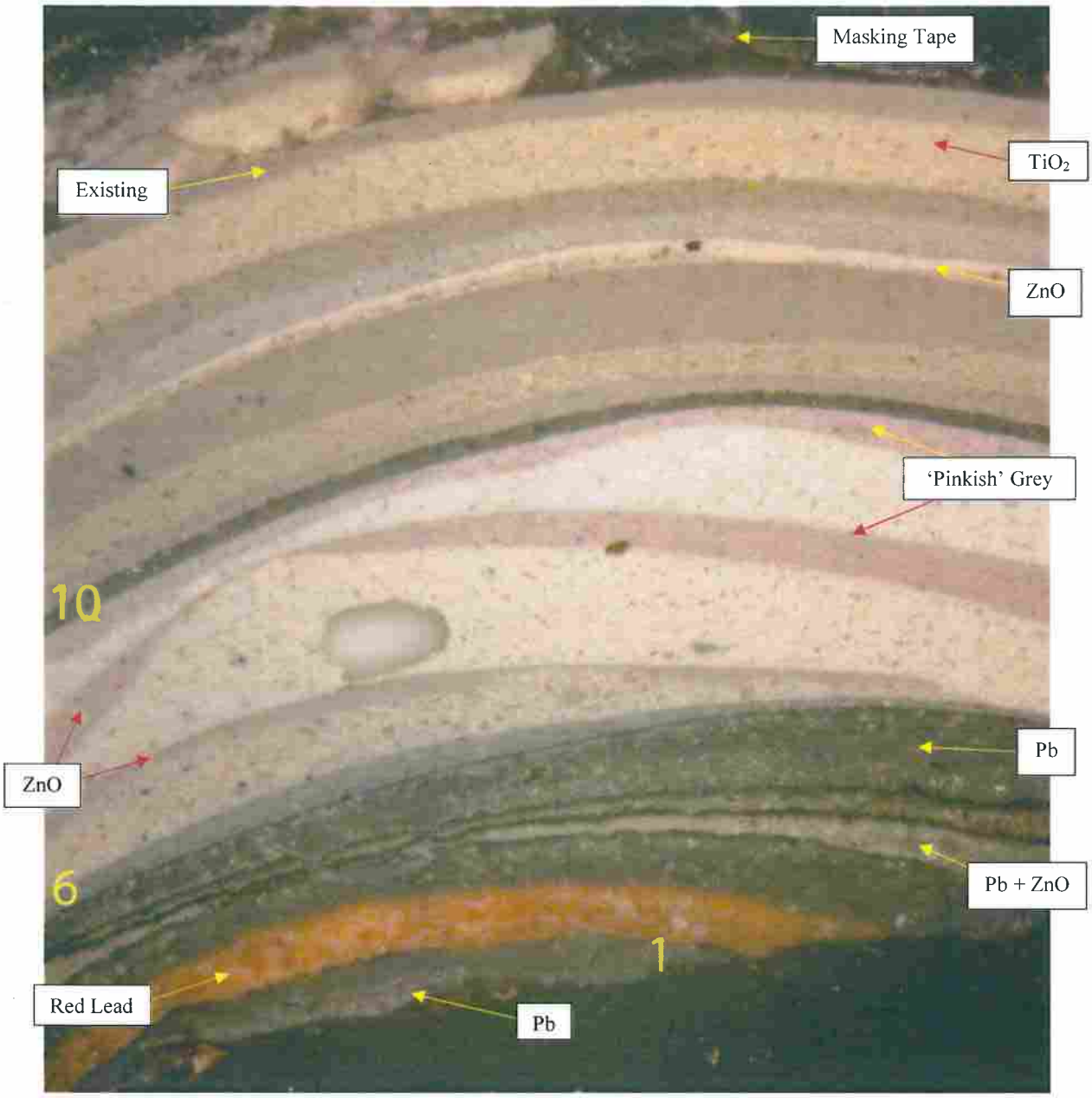
Photomicrograph of SHR/1 (x200)
S end. SW corner. Low rail on wall

Photomicrograph of SHR/5 (x200)
S end. L/H gate pier. Edge

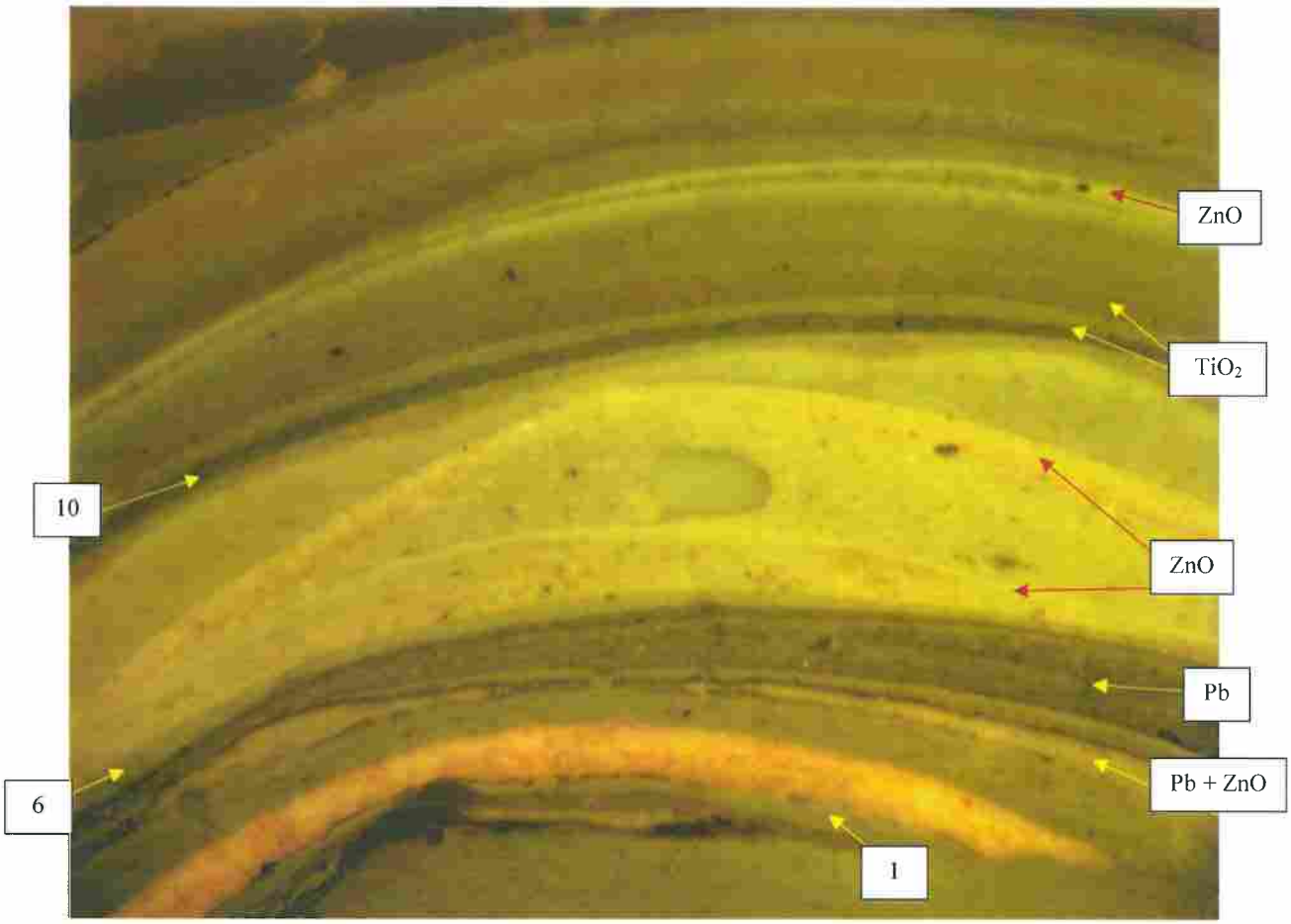
Photomicrograph of SHR/3 (x200)
S end. L/H gate pier. Decorative panel. Diamond



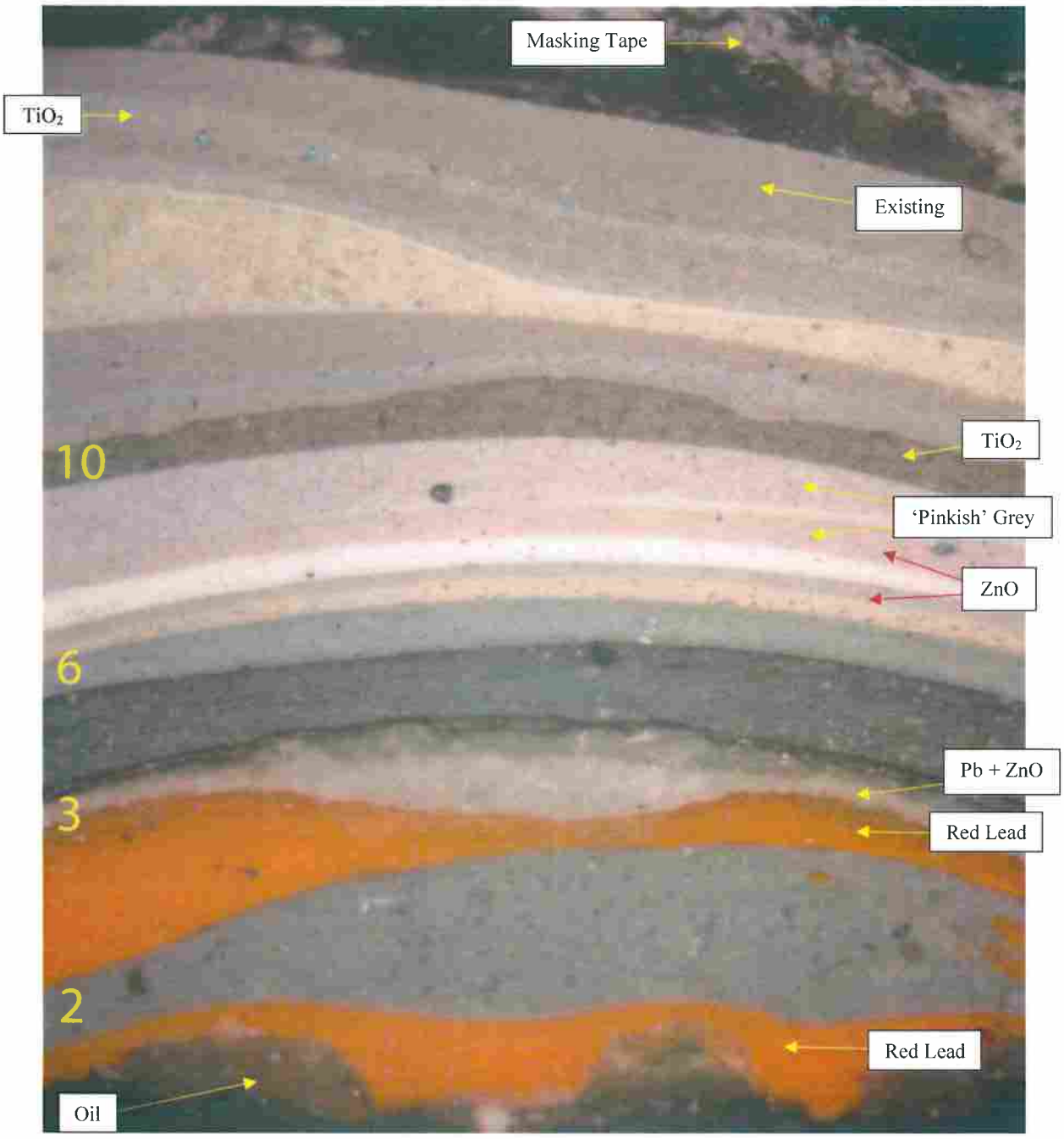
Photomicrograph of SHR/4 (x200)
S end. L/H gate pier. Decorative panel. Circle



Photomicrograph of SHR/6 (x200)
SW corner. Malet Street frontage. 4th decorative upright from corner. Edge



Photomicrograph of SHR/6 (x200 under UV light)
SW corner. Malet Street frontage. 4th decorative upright from corner. Edge



Photomicrograph of SHR/19 (x200)
N end. Main gates. Upright of panel between R/H main gates & R/H pedestrian gate

APPENDIX THREE

CROSS SECTIONS MADE

(Samples shown in **bold** are illustrated)

SHR/1	S end. SW corner. Low rail on wall
SHR/2	S end. R/H gate. RHS nearest hinge
SHR/3	S end. L/H gate pier. Decorative panel. Diamond
SHR/4	S end. L/H gate pier. Decorative panel. Circle
SHR/5	S end. L/H gate pier. Edge
SHR/6	SW corner. Malet Street frontage. 4th decorative pier from corner. Edge
SHR/7	SW corner. Malet Street frontage. Upright to R/H of SHR/6
SHR/8	SW corner. Malet Street frontage. Upright to L/H of SHR/6
SHR/9	S end. Pedestrian gate on Malet Street frontage. R/H Decorative panel. Edge
SHR/10	S end. Pedestrian gate on Malet Street frontage. R/H Decorative panel. Diamond
SHR/11	S end. Pedestrian gate on Malet Street frontage. R/H Decorative panel. Circle
SHR/12	Centre. R/H main gates. R/H decorative panel. Edge
SHR/13	Centre. R/H main gates. R/H decorative panel. Diamond
SHR/14	Centre. R/H main gates. R/H decorative panel. Circle
SHR/15	Centre. R/H main gates. R/H gate. RHS nearest hinge
SHR/16	Centre. L/H main gates. L/H decorative panel. Edge
SHR/17	N end. Main gates, R/H pier of R/H pair of gates
SHR/18	N end. Main gates. R/H pair of gates. R/H one
SHR/19	N end. Main gates. Upright of panel between R/H main gates & R/H pedestrian gate
SHR/20	N end. Goods gate. Pedestrian gates on RHS. R/H gate. R/H upright nearest hinge

APPENDIX FOUR

SOME PIGMENTS FOUND ON THE IRONWORK

White Lead

"White may be said to be the basic colour in all painting practice, for few pigments are used without the incorporation of some white to give body (opacity) or to reduce colour strength. Until some fifty years ago [about 1900] white lead was the only white pigment produced in any great quantity, but since then other whites have been introduced which have practically superseded white lead for some purposes, notably interior painting. In spite of certain drawbacks, however, white lead remains unsurpassed for exterior painting. The other principal basic whites used in this country are zinc oxide, lithopone, antimony and titanium".[24]

Zinc Oxide

Zinc oxide is a bright white pigment that is non-poisonous, and is not discoloured by sulphurous fumes. These properties led to its consideration as a replacement for white lead towards the end of the nineteenth century. One of the earliest references to it appears in a book of specifications published in 1859.[25] In this instance it was recommended in rooms with gaslights where the "clearness and brilliancy" of the white was to be preserved. Its chief disadvantage is the hardening effect it has on oil, which causes it to produce a hard non-elastic and brittle paint film. This may lead to premature breakdown of the paint on external surfaces by cracking or chalking unless corrected. In mixture with white lead it produces a very good paint. The zinc hardens the lead and helps it to maintain colour in a smoky atmosphere, while the lead moderates any hardening action of the zinc and so prevents brittleness. Paints containing such a blend of lead white and zinc oxide were used in the first quarter of the twentieth century.

The use of zinc oxide appears to have reached its peak in the second decade of the twentieth century. It was at this time that Arthur Jennings, the prolific writer on paint, wrote:

Before 1914 nearly the whole quantity of zinc oxide used in this country was imported from France, Belgium, Holland, and the United States of America, but since that time several factories have been started in England, and the present produce has already reached an output almost sufficient to fill all home requirements.[26]

Its appearance in paint stratigraphy usually indicates the period ca.1890-1960.

Titanium Dioxide

A pigment known as *titanium white*, which was a combination of titanium oxide and barium sulphate was introduced into Britain in 1921, and this rapidly became established as one of the staple pigments for paint manufacture. Towards the close of 1927, however, as a result of long experience and research, the difficulties of preparing a satisfactory pigment from the pure

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[24] (Hurst 1949, 61).
[25] (Donaldson 1859, xxi).
[26] (Jennings 1921, 1:184-185).

oxide were finally overcome, and a pigment of brilliant whiteness and intense opacity was introduced containing approximately 98 per cent titanium oxide. The outstanding qualities of this were soon recognised, and by the late 1940s it had largely superseded the original type of pigment for many purposes, although the composite pigment was still manufactured and used for a while. It has been the prime white pigment in house paints for the last forty years.

Red Lead

John Smith described very clearly the manufacture of red lead:

> this colour is made out of common lead, by first reducing it to a litharge; and that litharge being afterward ground to a powder in a mill is afterward conveyed into a hot furnace, for that purpose, where 'tis continually kept stirring with an iron rake, till it has attained to the colour of a fine, pale red.[27]

This pigment had a very mixed reputation, and was often used more for its drying properties, than its orange-red colour, which was liable to turn black in oil. Whittock said, however, that it kept its colour in water-based media, and was consequently, sometimes, used in distemper.[28] T.H. Vanherman (a London colourman) found little use for its colour in house-painting, except as a ground for mahogany graining.[29]

As well as being used in the manufacture of drying oils, this pigment came to replace Spanish brown or red oxide as a priming colour. Its quick drying nature was of considerable use at a time when a coat of oil paint could take several days to dry, and the decoration of a room, perhaps, a week. The addition of red lead to the undercoats would ensure that these would be ready to receive the finish coat as soon as possible. One consequence of this characteristic was that it was somewhat difficult to work with, hardening into an unmanageable mass,[30] and adhering:

> so strong to the bottom of the paint-pot, that it proves a troublesome task to liberate it and bring it into a working condition again.[31]

On internal surfaces the pigment was often mixed with size and used to kill knots, prior to painting.

Towards the end of the nineteenth century primers based on red lead dispersed in linseed oil began to be used on structural steelwork. Their use continued until the late twentieth century when the toxic nature of red lead became a concern.

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[27] (Smith 1687, 21).
[28] (Whittock 1827, 10).
[29] (Vanherman 1829, 29).
[30] (Tingry 1830, 106).
[31] (Vanherman 1829, 29).

Carbon Black

Lamp black was the soot collected after burning the resinous parts of fir-trees. It came mostly from Sweden and Norway, although it was manufactured on a large scale in Germany at the beginning of the nineteenth century.[32] John Smith referred to its being "made up in small boxes and barrels of deal, of several sizes, and so brought over to us".[33]

It was the most commonly used of the blacks, being cheap and plentiful. It was a very fine pigment, that would serve most needs, without grinding, if mixed up well with linseed-oil. If used in this manner, however, the greasiness would retard its drying time, unless a drying agent were added.[34]

Blacks, of various forms, were often added to white paint in order to combat the inherent yellowness of a lead white and linseed oil paint.

Chrome Yellow

Chrome yellow was the yellow pigment that the artist and the house-painter had been waiting for. It was the first bright yellow that was reasonably durable, and yet worked in both oil- and water-based media.

A Frenchman, Louis Vauquelin, is credited with the discovery, in 1797,[35] though it was not until some years later that sufficient supplies of the mineral, lead chromate[36] were available to enable production in any capacity. Rosamund Harley says that it was a German, called Bollman, in his factory at Battersea, on the Thames, who first manufactured the pigment commercially in England, in the second decade of the nineteenth century.[37]

Vanherman, writing in 1829, said that it:

> surpasses every other yellow, for brilliance, beauty, and intensity of colour, either as a full, or in its gradations when lowered with white. There are two sorts manufactured, the orange and the lemon: the first is a rich warm tint; the latter is cool, and elegantly delicate. They are both standing articles, when properly prepared...those specimens which are light are to be rejected.[38]

Tingry indicated the up-to-date nature of his third edition, when he mentioned that "for some time past, it has been prepared artificially in this country",[39]and claimed that it had superseded

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[32] (Tingry 1804, 347).
[33] (Smith 1687, 16-17).
[34] (Pocket 1825, 89).
[35] (Tingry 1830, 107).
[36] $PbCrO_4$.
[37] (Harley 1982, 100-102).
[38] (Vanherman 1829, 28-29).
[39] ((Tingry 1830, 107).

the use of patent yellow among coach-painters and house-painters. Its great advantage besides the "extreme richness and beauty of its colour" was that it possessed so much body:

> that one pound of it will go as far as four pounds of patent yellow. It is so fine that it requires no laborious grinding, but will spread readily under the brush, and may be laid on with varnish; it is not poisonous like King's yellow;[40] it will stand better than most other pigments; sulphuretted hydrogen-gas only impairing its beauty; against which, however, it may be protected by varnish. It makes also a beautiful green with Prussian blue. Care should be taken to obtain it pure, as it is apt to be adulterated with white lead or patent yellow, from both which it cannot be distinguished by the eye.[41]

Hay described it as "almost the only bright yellow now in use", commending the painter to purchase it from a manufacturer of high repute, and to pay as much as he could afford. He said that it came from the manufacturer in the form of "dry lumps".[42]

[40] It may not have been quite as poisonous as king's yellow, but it is classified as a toxic pigment.
[41] (Tingry 1830, 107-8).
[42] (Hay 1847, 108).

APPENDIX FIVE

SAMPLE ANALYSIS TECHNIQUES

Sample Preparation Procedures

Pigments
Samples of pigments from specific paint layers were permanently cast in Cargille Meltmount (with a refractive index of 1.66) onto microscope slides. The pigment samples were examined at 500x and 1000x magnifications under both transmitted, and plane polarized light.

The pigments were identified using polarized light microscopy (PLM) techniques which allows identification of different pigment particles based on the characteristics of particle shape, colour, refractive index, and optical properties. In certain instances, where further confirmation was required, energy-dispersive X-ray analysis (EDX), using the scanning electron microscope, was carried out.

Cross Sections
Samples of finish coatings and substrates were removed from representative surfaces in the rooms being examined with a scalpel, craft knife or dental drill. Depending on the material, the samples varied in size from 5mm to 10mm. The samples were divided before casting, leaving a portion of the sample available for future testing. Samples were cast in small cubes in silicon rubber moulds using clear casting polyester resin (Alec Tiranti Ltd, Reading, Berks.). The resin was allowed to cure for 24 hours at room temperature and under ambient light. The cubes were then cut in half to expose the cross sections, and wet polished with 240, 400, 600 and 1200 grade wet-and-dry papers.

The cross section samples were examined under visible light using a Biolam metallurgical microscope at 200x and 500x magnifications. Those that appeared to have the full sequence of layers, i.e. that displayed an intact sequence from the substrate through to the final scheme, were examined particularly closely. These intact samples were compared with those samples that were distorted or unclear, and with those that were incomplete. The combined information has provided the details in this report.

The cross sections were photographed digitally using a Nikon Coolpix 5000 camera. The best photomicrographs for each element have been included with this report. Photographs were taken at 200x and 500x. A number of the photomicrographs have been digitally enlarged or reduced to fit the page.

APPENDIX SIX

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