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PROCESSES, PIGMENTS, AND VEHICLES

GRINDING COLOURS ON THE MULLER

(A Half-tone Process Block from a Photograph)

FACTS

ABOUT

PROCESSES, PIGMENTS AND VEHICLES

A MANUAL FOR ART STUDENTS

BY

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PREFACE

THIS book is merely intended to form a simple and elementary introduction to a difficult and complex subject, which involves a considerable amount of scientific knowledge for its complete mastery. Those wishing to pursue the subject further must consult more advanced books.

The aims and scope of the book are fully explained in the Introduction, so that there is no need to say anything here beyond acknowledging how enormously I am indebted to Professor Church and his book on *Paints and Painting* for the information contained in the following pages.

I must also thank him here for the personal assistance he has always given me in my study of this subject; and must also thank Mr. Farmer, of the Regent Street Polytechnic, for his invaluable assistance while I was preparing the chapter on Process. I have tried to give a fair judgment of half-tone work; but there is such a marked difference between process prints as exhibited by process-block makers and as reproduced in books and magazines, that it is difficult to judge the process fairly. The process-block makers blame the printers, and this is probably the correct explanation. Captain Abney has proposed and is testing at South Kensington a method of protecting pictures by absorbing the more chemically-active rays of the light entering the Gallery, which should prove of great use. It does not, however, do away with the necessity of the precautions described in this book.

A. P. LAURIE.

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PART II

NOTES ON 'PROCESS,' AND ON TEMPERA, FRESCO, WATER-COLOUR, AND OIL-PAINTING

INTRODUCTION

THE object of this book is to give art students a practical acquaintance with the preparation and properties of pigments and vehicles, and to familiarise them with those more important facts which are of direct application to painting. Though it would be absurd to expect artists at the present time to prepare their own pigments, oils, varnishes, and canvases, yet it is necessary for the right understanding of their work that they should know the nature of these substances and something of their modes of preparation. He is a poor workman who knows nothing of his tools.

It is, however, difficult for them to understand scientific treatises on pigments, and there is little learnt by mere reading or listening to lectures. Real knowledge is to be obtained only through the actual seeing and handling of things. For this reason I propose to depart in this book from the usual method, and to put before the student a series of simple observations and experiments by which he may become practically acquainted with the nature and properties of pigments. By a small expenditure in cheap and simple apparatus, art schools will be enabled to put their students through an experimental course which will both interest them and impart a genuine knowledge of the subject, while any further information they may require can be readily obtained by consulting more comprehensive text-books, which will be readily understood after this preliminary training. In pursuance of this design the book has been divided into two parts.

The first part consists of a series of simple practical lessons on the properties and preparation of pigments, oils, and varnishes. The experiments should be performed by the student himself. The second part contains a brief chapter on the methods of process reproduction, and some notes on painting in tempera, water-colours, frescoes of different kinds, and oil.

Then follows in the Appendix an attempt at a complete list of pigments, with some information about their durability in different media.

Some apology and explanation is perhaps due for the chapter on 'Process.' While reproduction by photographic methods is being vehemently denounced by some, it is at the same time supplying a livelihood to many, and I am disposed to think that 'process work' has its legitimate place, among other methods of reproducing the work of the artist. While it does not replace in any way the good woodcut, or good copper or steel engraving or etching, it is a useful method for reproducing line work of a bold and simple character, and reproducing it accurately. Beyond this I doubt its value or permanent position as a method of reproduction. All half-tone work seems to me of doubtful value, and may be expected in time to disappear. But I hope that my chapter on process work may not be entirely useless from an artistic point of view; and that by pointing out some of the deficiencies and limitations of process work and its purely mechanical methods for the imitation of certain effects, it may help both artists and the public to realise its legitimate and humble place among methods of reproduction, and so may check the tendency to use merely mechanical dodges that deceive the untrained eye into the belief that it is gazing on the subtle work of the hand of the artist.

The production of a durable painting, whether on the wall of a building or on a panel or a piece of canvas, whether in fresco or in oil, in water-colour or in tempera, is a difficult problem; and because it is difficult, it is one to which the artist should devote considerable thought. For it is his duty not only to turn out a work of art, but also to turn out a good job, in which good materials have been used, and the best possible devices adopted to insure the permanency of the work. He should no more use fugitive paints than the carpenter should use unseasoned wood, and he should take at least as much trouble to prevent his work from fading and falling to pieces as the house-painter or coach-painter would do.

Unfortunately, the difficulties are many, and there is no one method or process which can be advised as perfect, each having its own defects and dangers. Then the multiplicity of new pigments discovered every day further enhances the difficulties and places new pitfalls before the unwary artist. And though modern chemistry, repenting somewhat of her evil deeds in inventing innumerable fugitive pigments, has lately turned her attention to the problem of how to produce durable pictures, yet at the end of the researches made by Professor Church and others, I doubt if we can claim to know so much about the subject as a fifteenth-century painter. The reason for this is not far to seek. The old 'prentice method of training artists resulted in the accumulation of invaluable traditions, traditions all the more useful, as in those days the painter prepared his own materials, or, to speak more correctly, employed his apprentice to do so. The apprentice was consequently familiar with every material and every process used in the production of a picture, and would himself observe the success or failure of the different processes and preparations on his master's picture years afterwards, and detect what was good and what was bad in the methods he had then learned. Then the number of pigments and of media was limited, and their properties, advantages, and defects were studied with slowly-accumulating experience, which was not disturbed by the discovery of new pigments or the introduction of old pigments under new fancy names. From the moment the colourman was separated from the artist, and the experimental chemist from both, all inevitably became confusion.

But these are not the only difficulties: not only has the artist lost the valuable training of apprenticeship, lasting, according to Cennino Cennini, ten years before the apprentice began to paint a picture, but he has further been overwhelmed by the rapid growth of modern chemistry, which has resulted in the production of large numbers of new pigments, and the development of a marvellous skill in imitation and adulteration. Even this does not complete the story; there is another factor, and that is the change that has come on the methods of painting themselves. It is useless to expect from the artist of to-day, painting rapidly, trying to grasp subtle effects of atmosphere and delicate evanescent shades and tones of colour, the patient building up of a picture from the beginning, with the use of varying media according to the pigment on the brush, and other devices to insure permanent work. Finally, a new enemy has arisen in the shape of coal, which, pouring out from every chimney powerful acids, and tarry particles which can eat into the oils and varnish, and sulphur compounds which darken the white lead and other lead pigments, puts the finishing touch on the troubles of the artist who wishes to produce a permanent piece of work.

There is, however, another side to this gloomy picture, and modern chemistry has not been wholly inimical to the artist. The older painters had to struggle with the difficulties of a limited palette containing notoriously fugitive pigments, and had to resort to many devices to protect them from change. The discoveries of modern chemistry, while adding enormously to the list of fugitive pigments, has also added to the list of permanent ones, and consequently has put at the command of the painter of to-day an ample palette of pigments which may be trusted to resist change, and would have excited the envy of Van Eycke. Added to this, the systematic and useful experimental work carried on by Professor Church, Professor Russell, Captain Abney and others, is rapidly resulting in more and more exact information as to the properties and behaviour of vehicles and pigments, so that the artist of to-day who chooses to avail himself of the results of all this work, may hope to produce fairly durable pictures. The great point is the careful selection of the palette. There is no difficulty in obtaining all the pigments necessary, and yet avoiding fugitive pigments, or pigments which act injuriously on each other. But in selecting the palette it must be remembered that each process requires a different selection, and that the list of pigments suitable for oil paintings is not suitable for water-colour or fresco. One of the principal reasons why so many modern efforts at fresco have come to grief, is that those painting in fresco have not realised the rigid limitations of the art caused by the fact that few pigments can withstand the action of lime. Cennino Cennini writing in the fifteenth century mentions only five pigments which can be safely used in fresco, but this number can now be increased by the inclusion of certain modern pigments which may safely be trusted.

Besides the selection of pigments there are other matters of much importance which the artist must bear in mind. For instance, in using oil as a medium, the artist obtains the advantage to a certain extent of protecting his pigments from external influences; but, on the other hand, he has the disadvantage of using a medium which is apt to yellow and to crack. Yellowing can be cured by placing the picture in a window, and exposing it to bright light, while avoiding the direct play of the sun's rays upon it, and this process can do no harm, *if permanent pigments have been used.*

Cracking is a more serious question, and one difficult of solution. It is probably in most cases due to too hasty painting, and to the use of rapid dryers, but in many cases it happens in a most capricious manner, which is difficult to account for. Too hasty varnishing is also recognised as a serious evil, causing the picture to crack, but after all these admissions there is much here which has never been explained.

In water-colour painting, again, the pigments are left on the paper with no protection, and consequently a limited palette is here necessary if change is to be avoided, and care must also be taken to protect the picture from mechanical rubbing of the surface, which is sure to remove some of the colour. The question of the preservation of valuable water-colours is one which has excited considerable controversy, and does not yet seem to be decided, but there are two things to be borne in mind. In the first place, the pigments used by the older painters in water-colours were not selected with any scientific skill, and consequently contain fugitive pigments. In the second place, it has been proved by many experiments that these fugitive pigments are not seriously attacked by air and moisture if kept in the dark, but are rapidly attacked in sunlight, and more slowly in ordinary diffused daylight. Valuable water-colours should therefore be kept in the dark, and only exposed to light when being actually examined. They should also be kept dry, and free from dust and dirt. Probably the best plan for water-colours in public galleries would be to fit them with spring blinds, working the reverse way to those usually found in private carriages; the spring or attached weights keeping the blind *down*, when not pulled up by hand. An arrangement could be added for fixing the blind up if necessary when a picture was being copied, but this should be done by a key in the possession of an official. In this way the protection of the water-colours from light would be insured.

For the preservation of valuable oil pictures it is advisable, after careful cleaning of the surface and drying, to cover them with a thin coating of mastic varnish. This forms a protective coating which can be easily removed and renewed at any time without injuring the picture beneath, thus keeping it clean and free from the attacks of acids and tarry matters derived from coal fires and gas jets.

A picture gallery should be neither too dry nor too moist, and should be kept, if possible, at an equable temperature. Many a picture has been doubtless destroyed by the absorption of moisture by the canvas, and then by the freezing of the moisture during the night and thawing during the day, cracking off the ground.

On the whole it is advisable to protect the backs of canvases. This can be done in various ways, which will be described later on.

Panels can always be protected by a good coating of oil paint on the back and edges.

Though it is necessary to include a description of fresco painting in a book of this kind, it should, I think, be discarded in this country, especially in large towns and factory districts, for spirit fresco. It is so very difficult to clean a real fresco successfully. Professor Church has recently, however, accomplished this difficult feat by cleaning the fresco by Watts in the Inns of Court. This he managed by carefully going over the surface with spirits of wine and cotton wool. He then, after cleaning, sprayed the whole with his spirit fresco medium, so as to protect it in future from change. A similar process might be adopted for the preservation of other frescoes which are suffering from the exposure of their unprotected surface to damp and dirt and injurious gases.

Much more attention should be given to the condition of the atmosphere in our public galleries, little or nothing being now done to protect the pictures from change. There is no reason why the air should not be carefully filtered from dirt and smoke particles, injurious substances such as sulphuric and sulphurous acid and sulphuretted hydrogen removed, and the temperature and amount of moisture exactly regulated. It is also worthy of trial whether the life of water-colours might not be prolonged by keeping them in cases, in which the air was dried artificially by passing it over calcium chloride or quicklime. The expense of such precautions is trifling when compared with the priceless value of the collections in the National Gallery and South Kensington. But we have more to do here with the production of modern pictures than the preservation of old ones, and I shall therefore now pass on to treat of the properties of a selected number of pigments and vehicles.

PART I

AN EXPERIMENTAL COURSE ON PIGMENTS AND VEHICLES

CHAPTER I

HOW TO GRIND A PIGMENT IN WATER, OIL, OR OTHER MEDIUM

For this purpose a muller and slab must be obtained. These are made of various sizes, but a muller $2\frac{1}{2}$ inches in diameter and a stone or glass slab 9 inches each way are all that is needed.

The colour mixed with water or oil, as the case may be, is ground upon the stone with the muller.

The muller is moved over the stone with a circular motion, or backwards and forwards, and the movement is so regulated as to keep the colour *in the middle* and not let it run towards *the edges* of the stone. Skill is soon obtained by a little practice.

Of course the pigment collects round the muller, and must be scraped off with a spatula and placed in the middle of the stone again.

If any quantity of colour is to be ground, it is best to use two spatulas, one for placing the unground pigment on the stone, the other for scraping up the ground colour and putting it on one side. Before beginning, mix the pigment with the medium into a fairly stiff paste, and then lift up a little portion (for a muller of the size described, a portion about the size of a filbert), place it in the middle of the slab, and begin grinding with the circular action already described. When the colour is sufficiently fine, scrape it off the stone slab with the clean spatula. This is best done by running the spatula, lying nearly flat, across the stone, then turning the edge free from colour downwards, and giving it a tap on the stone so as to cause the colour to slide from the edge towards the middle of the blade. Then give another scrape to the muller, and so on till all the colour has been removed. If the muller is not overloaded with colour, no difficulty will be found in grinding the colour fine.

Whether the colour is sufficiently fine can be judged by rubbing a little out with the finger on the blade of the spatula or on a piece of glass, or porcelain glass, or a common white plate. When fine it should rub out smoothly and not show any separate coarse particles. The degree of fineness, however, can best be judged by comparing it with the same pigment as supplied by the artist's colourman.

The frontispiece shows colour being ground on a large slab with a big muller, the heap of colour ready for use lying in one corner, and the two spatulas lying in position. The drawing also shows how to hold a large muller. In the case of a smaller muller only one hand is used.

If the slab tends to shift about during the grinding, it is easily fixed in position by means of two pieces of wood screwed down to the table on each side of the slab.

Mullers and slabs are made of glass, marble, granite, etc.

I prefer a muller made of some hard pebble, and a marble slab, but the other materials are quite satisfactory.

Experiment 1

Practise grinding a little yellow ochre in oil, comparing the result you obtain with a commercial sample.

You will obtain the same degree of fineness with ease, but *not the same consistence.* Your pigment will be *thin* and *treacly*, not *stiff* and *crisp.*

The secret of this stiffness will be explained later on. It is of no importance to us just now.

Experiment 2

Clean the muller with some turpentine or paraffin and an old rag or handful of waste, and practise grinding some yellow ochre in water.

This is more difficult, as the muller is *apt to stick* to the stone, and some practice is needed.

Clean the muller and slab with a little soap and water.

Having now learnt how to grind small quantities of pigments, we shall proceed next to the question of how to test their durability.

CHAPTER II

ON THE TESTING OF THE DURABILITY OF PIGMENTS BY EXPOSING THEM TO LIGHT AND AIR

THE durability of pigments depends on many conditions. They may be altered by contact with other pigments or by contact with impure paper, or badly-prepared grounds, or injurious media; they may be affected by special gases present in the atmosphere. These different causes of change we shall examine in due time. But in the majority of cases pigments yield simply to the action of *light*, *air*, and *moisture*. This gives us a very convenient method of applying a simple test to decide whether a pigment is durable or not.

The action of air and moisture is enormously increased by exposing a pigment to a strong light. So much so that Captain Abney has calculated that two years' exposure to the direct light from out of doors is equivalent to four hundred years' exposure to the light of a picture gallery. Some realisation of the enormous difference between outdoor and indoor light may be obtained by noticing that a room looked into from the outside seems to be quite dark. By therefore exposing pigments to direct daylight, we can in a few months classify them, and separate those that are fugitive.

I shall begin by describing how water-colour washes may be examined. This *may* be done by starting from the pigment as supplied in water by the artist's colourman, but it is better to prepare from the dry pigment, grinding it with a muller in water.

Prepare some colour by grinding it on the muller with water, removing the paste to a little wide-mouthed bottle, and then adding a few drops of gum arabic solution. Common gum should not be used, but some pure gum arabic should be bought at a chemist's, and then dissolved in warm water. This is best done by putting the gum arabic and the water in a bottle and then placing the bottle in a saucepan of hot water which is kept nearly boiling beside the fire. If from time to time the bottle is shaken up the gum arabic will dissolve without difficulty.

Next dilute the pigment in the little bottle with sufficient water, and dip into it a large soft brush, and paint out a thin light wash of colour on a strip of Whatman's paper about six inches long by three inches broad.

Cork up the bottle containing the colour and allow the wash of colour on the paper to dry completely.

When dry, thoroughly stir up the colour in the bottle and lightly lay on a second wash of colour over the first, using all the paper except a strip about one inch broad at the bottom. Again allow the paper to dry, and again lay on a wash of colour over all the paper except a strip at the bottom about two inches broad.

This process is repeated until five washes have been laid on (this is a convenient number), the top of the paper being coated with five washes, the next portion with four, the next with three, and the last strip at the bottom with only one.

We have thus prepared a graduated scale for measuring

WASHES OF CRIMSON LAKE

depths of colour, and if we have been careful to mix the pigment thoroughly with the water each time, and to keep the bottle corked between whiles, each wash of colour will roughly correspond in strength to the others. The amount of dilution of the pigment required will be proved by one or two trials. The washes of colour should be strong enough to show clearly the difference between the first and second wash, and at the same time they should not be so strong that the distinction between the fourth and fifth wash is not clearly marked. Having thus prepared the paper of graduated tints, secure a cheap picture frame with glass in front and easily-removable back, and cutting off half of the top of the paper coated with five washes, fix it into the inside of the glass with some bits of stamp paper at the corners, and replacing the back, hang the picture frame up in a window, so that it shall get all the light going.

A very large number of tests can be made in this way on a single sheet of glass, each piece of paper being about one inch each way, and so occupying very little space.

The piece of paper should be numbered, and the number should be entered in a book, with a statement as to the nature of the pigment and the date of exposure, and space left for further entries. The graduated washes of colour should be kept in a drawer, dry and free from light.

From time to time the piece of paper pasted on the glass is compared with the graduated washes, and any change of tint with the date entered in the book, and the amount of fading measured by comparison with the graduated washes of colour.

Furthermore, it is as well to expose along with the pigment some well-known fugitive pigment like crimson lake, so as to compare the results obtained.

In fact, the student had best prepare a large sheet of paper with crimson lake in five washes, and keep it in the dark, and from time to time cut off small portions and expose it beside the pigment he is testing. In this way he will get a single standard of comparison.

Experiment 3

Prepare as described five washes of crimson lake and of a strong madder lake, and expose a portion of each side by side, and note the changes in each from time to time.

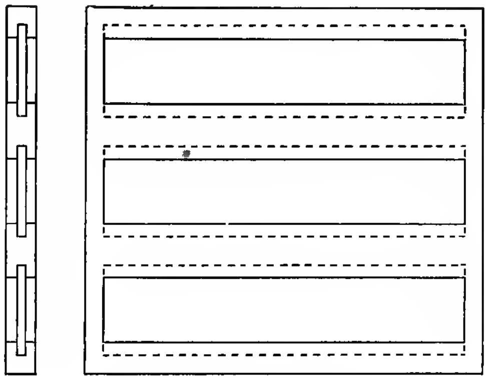
Durability of Pigments in Oil

The method just described is of the first importance, but it is also as well to test how far pigments are permanent in oil, as well as in water. Unfortunately, we cannot obtain in this case a numerical measure of fading, but we can, nevertheless, collect much useful information.

For this purpose get a box for holding 'quarter plates' from a shop which supplies photographic requisites, and obtain from a glazier's a set of glass plates, double the length of 'quarter plates.'

Grind the colour to be tested in oil, and rub out a patch of the colour as evenly as possible in the middle of the plate. The oil used should be a quick drying pale boiled oil, as, if raw oil is used, the pigment will take a long time to dry.

Next put the plate away in some convenient corner to dry, in the dark, and free from dust. When dry cut the plate neatly in half, right through the patch of colour. As this requires some special skill, it is best done by a glazier. Place a label with a number referring to the entry in your note-book on each plate, and put one half away in the quarter-plate box, and expose the other half to direct daylight. A very convenient arrangement for doing this is a wooden frame. It contains grooves for the plates to slide in, and along one side the groove is cut right through the wood so as to make a slit by which the plate to be tested can be slid into the frame. The frame can then be hung up outside or in a window close to the glass. From time to time compare the two halves of



FRAME FOR EXPOSING OIL COLOURS

glass by laying them together as they were before cutting, and judge how far the pigment is fading, entering the result, with the date, in your note-book.

Experiment 4

Compare in this way the fading of crimson lake in oil with the fading of crimson lake in water.

We have now learnt how to test the durability of pigments, and in future when we examine the properties of a pigment, we shall expose a portion of it to light after the manner described above, so as to collect information as to the durability of pigments.

We shall now pass on to the consideration of the properties of the earths.

CHAPTER III

THE YELLOW OCHRES AND RAW SIENNA

The large and important group of pigments included under these names are of great value to the artist. They have this in common, that they are natural pigments which owe their colour to the presence of iron in combination, and having been produced by the slow action of moisture and other agents are remarkably durable.

The ochres are Yellow Ochre, Golden Ochre, Oxford Ochre, Roman Ochre, and closely allied to these raw sienna.

These ochres are obtained by mining in various parts of the world, in Oxfordshire, Derbyshire, Wales, Cornwall, and parts of France and Italy.

After removal from the mine the crude ochre is either mixed with or ground with water. The coarser particles are then allowed to settle, and the finer particles, which are still floating in the water, are drawn off into another tank and some of the ochre allowed to subside. The water is then drawn off, and the still finer particles allowed to subside in a second tank, and so on, usually four tanks being used in succession.

In this way the ochre, which is a yellow clay and easily suspended in water, is separated from the stones and sand mixed with it.

The process can easily be illustrated with a little garden soil.

Experiment 5

Dry some garden soil and sift it through muslin to remove the stones, roots, etc., then grind in a mortar for a few seconds with some water, pour the water carefully off into another vessel, again grind the soil with water, pour off the water, and repeat the operation until the water comes off clear and free from mud.

You will now find in the bottom of the mortar *coarse sand*, while if you allow the mud in the second vessel to subside for some time and then pour off the water, you will find a *fine sticky mud.*

When the ochres have thus been separated from sand and other impurities, they are dried at a gentle heat, and are ready to be ground in oil or in any other painting medium.

Ochres are yellow clays, and in a sense could be obtained almost everywhere, but it is only in certain localities that they are found sufficiently fine in colour to be worth preparing for use by painters.

Though we have seen how ochres are prepared, we have not yet decided to what the colour of the ochre is due, and as this is a matter of considerable importance, we must settle it by means of a simple chemical test.

Experiment 6

Take a little piece of thin iron wire and boil it up in a test-tube for a few minutes in *hydrochloric acid* with the addition of a crystal of *chlorate of potash.* Most, if not all, of the iron will dissolve. Now dilute the yellow solution with water, and add a few drops of a solution of *potassium ferro-cyanide.* A deep blue precipitate is at once formed in the solution. This precipitate we shall have to mention again later on, but at present we can use it as a simple means of detecting the presence of iron in a liquid.

Experiment 7

Now boil up a little dry yellow ochre in the same way with hydrochloric acid and chlorate of potash and add potassium ferrocyanide. We shall at once obtain **the same deep blue precipitate,** thus showing the **presence** of **iron** in the **ochre**. It is to the presence of certain compounds of iron that the yellow colour of the ochre is due.

Having then settled this question, let us next compare different ochres together both in powder and in oil.

Experiment 8

Grind a little pinch of each ochre you wish to examine on the muller with a few drops of oil, scrape it up with a spatula and rub it out with the finger on a white plate. On comparing these different ochres together you will notice that they differ both in colour and transparency; the pale yellows being somewhat opaque, while the browner shades approach nearer to raw sienna in character. Not only so, but if the ochres sold by different colour-makers are compared, they will be found *to vary considerably*, the yellow ochres and the golden ochres of one firm differing from those of another. The reason of this is not far to seek. Enormous quantities of yellow ochre are mined every year and brought into the market for house-painting purposes. But every now and then a 'pocket,' as it is called, of especially fine ochre is found, and is offered to the artists' colourmen. Each find may be secured by one firm or another and may last them for many years, but no two pockets will produce two ochres exactly alike.

Raw Sienna

This is an ochre containing a little 'manganese' (a substance which we shall consider later on) as well as iron. It is found in the neighbourhood of Rome, and forms the last of the series of transparent brown ochres.

Ochres are seldom adulterated, but Professor Church has occasionally found them brightened by the addition of a yellow lake, and I have found them brightened in the same way by the addition of chrome yellow. Both these practices are very objectionable. The addition of yellow lake is objectionable because the lake fades quickly, the addition of chrome yellow, because chrome yellow is so easily darkened by sulphur compounds. To prove this,

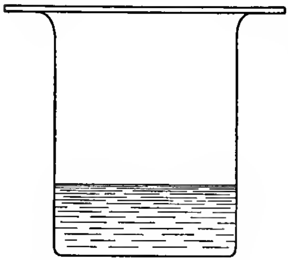
Experiment 9

Mix a little chrome yellow and yellow ochre together, and grind them in oil and rub out the colour on a white plate.

Now rub out on the same plate a pure yellow ochre ground in oil but not mixed with chrome.

Next pour into a small vessel a little *sulphide of ammonium*, and add to it some *hydrochloric acid*. Some sulphuretted hydrogen gas will be given off, and may be recognised by the smell of rotten eggs.

Cover up the mouth of the vessel with the plate containing the patch of yellow ochre and the patch of yellow ochre and chrome mixed, leaving it on the vessel for a few seconds so as to expose the pigments to the gas. On examining each patch, the yellow ochre will be found unchanged, while the chrome yellow will have turned dark brown.



BEAKER AND GLASS PLATE

This experiment shows how injurious the presence of chrome yellow may be. Its presence may be recognised in the way just described or in the following manner :—

Experiment 10

Boil the dry mixture of chrome yellow and yellow ochre with a little *sulphuric acid* and *spirits of wine.* If any chrome is present, the spirits of wine will turn dark green.

Yellow ochres, when pure, are quite permanent, and do not affect other pigments.

Experiment 11

Expose a wash of yellow ochre as directed in Chapter II. to light.

CHAPTER IV

THE RED OCHRES AND TERRE VERTE

HAVING now considered the yellow ochres, we pass naturally to the consideration of the red ochres, which are derived in many cases from them. These are known as—

Red Ochre, Brown Ochre, Red Oxide, Venetian Red, Light Red, Indian Red, Purple Ochre, Purple Oxide, Mars Red, Mars Purple. Burnt Sienna, Rouge, etc.

There are two common ways of preparing these pigments, and the first of these is gently roasting a yellow ochre.

Experiment 12

Gently roast a little yellow ochre on a sheet of iron over a *Bunsen burner*, or over the fire, turning it over and over all the while. It will rapidly turn of a bright red colour, and if the heating is continued the red will become of a more purple shade.

Grind a little of this pigment in oil and compare its colour with commercial red ochres.

Paint out a wash of this pigment in water and expose to light.

In this simple way can red ochre be obtained, and by a longer and stronger heat purple shades can also be prepared.

Experiment 13

There is another method which is, however, not so good for artists' purposes, and that is the roasting of *green vitriol* (*sulphate of iron*).

This substance is a salt of iron, as can easily be proved by dissolving a few of the green crystals in water, boiling with a few drops of hydrochloric acid and chlorate of potash, and then adding potassium ferrocyanide. A dark blue precipitate is at once produced.

Experiment 14

Grind up a few crystals of sulphate of iron into a coarse powder in the mortar, and heat them strongly for some time on a piece of platinum foil in the flame of a Bunsen burner. They will first of all turn white and then red in colour. Take a little of the red powder which is left and grind it in oil, and compare it with the roasted ochre.

This is the second important way of preparing these reds, though it may be questioned if they are as safe to use as those prepared from roasting ochres, and while they are lighter, they are somewhat harsher in colour.

If a red is prepared in this way, it should be well washed with hot water and dried before being used for artists' purposes, as it *may* contain traces of acid compounds from imperfectly decomposed portions of the green vitriol.

To prepare lighter shades, these red ochres may be mixed with fine whiting (chalk), or fine gypsum (sulphate of lime). This is a legitimate method of obtaining lighter shades, the intermixed substances being quite harmless, and the custom dating back as far as the fifteenth century, and probably much farther.

After what has been said about the varieties in shade occurring among ochres, we naturally find the same to be true of the red ochres.

Not only does each maker sell several different shades from light red to purple, but if the light red, Venetian red, or Indian red of different makers are compared together, they will be found to differ considerably in shade and brilliancy of colour.

Burnt sienna is, of course, prepared in the same way by roasting **raw sienna.**

This pigment is hard to grind, and requires to be ground very fine in order to bring out the rich glowing transparent tints of which it is capable.

These red ochres are all absolutely permanent and do not affect other pigments.

Terre Verte

This is another pigment of a soft grey-green shade which owes its colour to iron. Unfortunately it is no longer obtainable of so fine a colour as the terre verte used in the fifteenth and sixteenth centuries, so that it is not used so much as formerly.

Experiment 15

Grind a little terre verte in water and in oil and note the colour.

Expose a wash of the pigment to light.

It is absolutely permanent and does not affect other pigments.

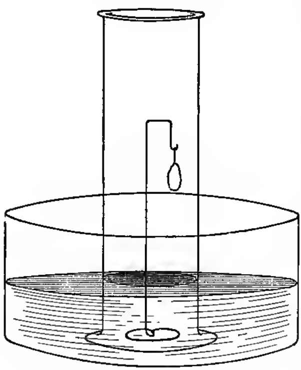
It will be noted that all the pigments described up to this point owe their colour to iron.

This is due to the fact that iron is able to combine with the oxygen of the air and with water to make several different compounds of different colours.

If a piece of iron is exposed to damp air it *rusts.*

This **rust** is a combination of iron with oxygen, which is red in colour.

In the same way the red ochres are all compounds of iron with oxygen, mixed with other things, and according to the amount of oxygen present, vary from red to purple in colour. That iron does combine with the oxygen of the air to form these 'red oxides,' as they are called, is easily proved by a simple and pretty experiment.



REMOVAL OF OXYGEN FROM THE AIR

The reader is already probably familiar with the fact that air is a mixture of two gases, oxygen, the supporter of life and combustion, and nitrogen, which is inert, and serves to dilute the oxygen. The removal of the oxygen from the air by rusting iron can easily be shown in the following way :—

Experiment 16

Take a piece of stout copper wire and bend the bottom into a circle so as to enable the wire to stand upright, and form the top into the shape of a little hook.

Stand the wire upright in a dish of water and attach to the hook a bundle of clean iron filings free from grease, and steeped in a solution of *salammoniac*, and tied up in a piece of muslin.

Place an inverted glass cylinder over the whole. Leave the apparatus alone for a day or two.

As the iron *rusts* or *combines with the oxygen*, the water gradually rises in the cylinder, until it occupies about $\frac{1}{5}$ of the whole volume of the cylinder. This means that all the oxygen has now been removed, as $\frac{4}{5}$ of the air consists of nitrogen.

Now turn the cylinder sharply over and insert a lighted taper.

The taper at once goes out, showing that the oxygen has been removed, and nothing but the inert nitrogen has been left.

The green and yellow pigments which owe their colour to iron contain compounds of iron, oxygen, and water.

This can easily be shown in the following way:—

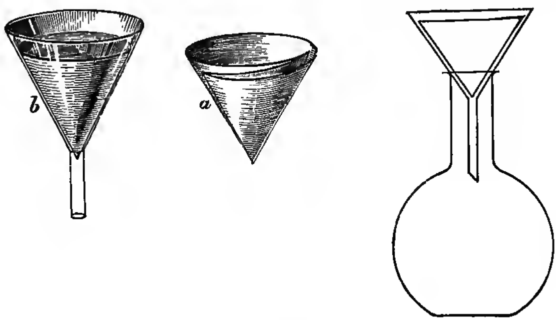
Experiment 17

Prepare a solution of green vitriol and add *ammonia* to it. A green precipitate of iron, oxygen, and water combined together is at once thrown down.

Now pour the whole solution and precipitate on a filter paper placed in a funnel, and allow the liquid portion to drain away, leaving the precipitate behind.

(This operation requires a little explanation. 'Filter papers' are cut circular in shape, and are made of unglazed porous paper. They enable liquids to be completely separated from solids suspended in them, the liquid escaping through the pores. If you wish to 'filter' a liquid, take one of the filter papers, fold it in half, and fold it again so that it is cone-shaped.

Now open it out so as to make a little cone-shaped bag,



FILTRATION

fit it into a glass funnel, and pour in the liquid to be filtered. When a filter paper cannot be obtained, a piece of blotting-paper will do.)

After filtering the liquid, open out the filter paper and leave the green precipitate exposed to the air.

It will gradually turn of a brownish-yellow colour, thus showing the formation of another compound of iron, oxygen, and water, to which the yellow colour of ochre is due.

This completes all we need know about ochres, and we can pass next to consider another group of earths, the umbers.

CHAPTER V

THE UMBERS

We have seen the importance of iron as a colouring matter, and we have now to examine a new substance, to which the colour of the umbers is largely due.

The umbers contain compounds of iron, but associated with the iron are compounds of a metal, to which the name '*manganese*' has been given. Possibly many of my readers have never heard of this metal before, and yet, though the metal itself in a pure state is of no value in the arts, its compounds are frequently used for various purposes.

As we shall see when we come to study the preparation of oils, the compounds of manganese supply us with the most valuable kinds of *dryers*, by which boiled oils and drying oils can be prepared. In the meantime we shall only consider its importance as forming part of the colouring substance in the umbers.

One of the commonest varieties of manganese is the *black oxide;* this is found in large quantities as an ore, and has sometimes been used as a pigment.

Experiment 18

Take a little black oxide of manganese, note its colour, grind a little in oil and note the colour of the pigment obtained. This metal is present in umber, and gives umber its fine dark brown colour.

The finest umbers come from Cyprus, though umber is also obtained in Devonshire, Derbyshire, Cornwall, Wales, and parts of France, Italy, and America. The pigment is obtained by mining, and is then ground with water and floated over, as we have already seen in the case of the ochres, dried, and is then ready for grinding in oil.

On comparing the umbers sold by different makers, they will be found, like the ochres, to differ considerably in shade and in the quality of the colour.

The finest Cyprus umbers have a greenish tint, which gives a brown of a peculiarly rich quality.

Experiment 19

Grind in oil and compare Cyprus umber with common umber, and notice the difference in the richness and quality of the colour.

The umbers, owing to the manganese compounds they contain, act as powerful dryers, and consequently in some cases the pigment becomes hard and unusable in the tube from the action of the umber upon it.

Experiment 20

Grind a little Venetian red and a little raw umber in raw linseed oil, rub out a little of each on a piece of glass, and put the glass aside.

Examine from time to time, and note which patch of colour dries first.

Burnt umbers are of course prepared by gently roasting *raw umbers*.

Experiment 21

Gently roast a little finely-powdered umber on the iron plate used to roast yellow ochre, then grind a little in oil, and notice the warm red tint which has taken the place of the brownish green tint of the raw umber.

Umbers are permanent, and do not affect other colours.

Experiment 22

Paint out a wash of umber and expose to light.

Cappagh Brown

This is an umber of a particular shade obtained in Ireland. It is used to some extent by artists, and corresponds to the other umbers in its properties.

Experiment 23

Grind some Cappagh brown in oil and compare the tint with raw umber.

CHAPTER VI

THE BITUMENS AND BITUMINOUS EARTHS

In certain volcanic districts a tarry substance is found corresponding closely in its composition and properties to the black residue left in a retort on distilling coal-tar.

This substance belongs to the group of *organic* substances, and will burn in the air with a smoky flame.

It is known as Asphaltum, and a special quality of it found in Palestine is known as Bitumen of Judea. It is, however, difficult to distinguish the artificial from the natural substance, and bitumens of various origins are used as pigments.

Experiment 24

Take a piece of Bitumen of Judea and a piece of asphaltum prepared from coal-tar, notice the appearance of each, and heat a little of each in the Bunsen flame.

They both melt, then begin to boil, and then catch fire and burn with a smoky flame and a strong acrid smell.

These substances, when ground in oil, yield beautiful transparent browns, which are permanent when exposed to light.

They are of little use as water-colour pigments.

Experiment 25

Grind the samples of bitumen both in water and in oil, note their appearance, and expose a wash of both to light.

There is, however, a serious objection to their use in oil-painting, and that is the tendency they have to *flow.*

These bitumens belong to an interesting class of bodies which are intermediate between solids and liquids. If struck by a sudden blow they are hard and brittle, and break up like a piece of glass. If, on the other hand, they are exposed to the slightest pressure for a long period of time, they gradually yield to it and flow like a liquid.

Experiment 26

Melt some bitumen in a ladle over the fire, and pour it out into the round tin lid of a tobacco-box. When cold, place on the top of it a halfpenny and put it away. In the course of weeks, or may be months, the halfpenny will slowly sink into the bitumen by its own weight.

It is for this reason that the use of this pigment has been given up, the most extraordinary results having followed from its reckless use by the painters of forty or fifty years ago, in some cases portions of the picture having actually slid down the canvas.

At the same time there can be no doubt that it was successfully used by the 'old masters,' and apparently, judging by old receipts, their secret was to melt it over the fire and let it boil for some time, then take the hard mass left behind and *grind that* in oil.

In this way a pigment is obtained of fine quality, though not so fine as that obtained from the ordinary bitumen, and requiring somewhat prolonged grinding.

I am also disposed to think that if the bitumen is used as a *very thin glaze* it is not injurious, but the pigment has fallen into such discredit that it will probably be a long time before confidence is restored and artists feel safe in using it even after careful melting and boiling. This is, I think, a pity, as it has certain qualities which no other pigment can replace.

We come next to a group of very dangerous brown pigments which are earths, and which owe their colour largely to the intermixture of bituminous substances.

Though bitumen itself stands exposure to light, these bituminous earths do not do so, and consequently must be avoided. They are **Vandyke brown, Cologne earth, Cassel earth.**

Of these, Vandyke brown is the one most used. Some varieties are free from bituminous substances, but are very poor in colour, and therefore valueless.

Experiment 27

Take a little dry Vandyke brown. Place it in a test-tube and heat strongly. Notice the tarry matters which distil off with strong acrid smell.

Experiment 28

Paint out a wash of Vandyke brown and expose to light. It will be found to *slowly* fade.

This fascinating pigment is regarded as indispensable by some artists, while others regard its use as a proof of incompetence. There is no doubt it should be struck out from the palette.

We have now dealt with the principal earths.

There are no other natural pigments of practical importance, as the malachite greens (green copper ores) are little used, and real ultramarine, prepared from lapis lazuli, is a glorious but too expensive pigment. Of these I shall speak in the proper place, but must now proceed to consider the more important of the *artificial* pigments, and shall begin with the whites.

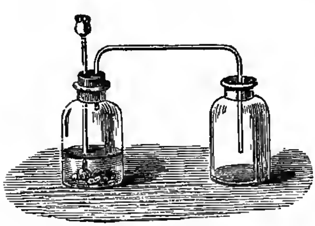
CHAPTER VII

WHITE LEAD (FLAKE WHITE), BARYTES, ZINC WHITE, LEAD SULPHATE

We have already seen how iron in combination with the oxygen of the air yields a series of valuable pigments. We must now study briefly the properties of another gas which enters into the composition of white lead, and the name of which is probably familiar to us all, viz. *carbonic acid gas.*

Experiment 29

Place a few pieces of broken marble in a wide-mouthed bottle and pour on the top a little hydrochloric acid. At once the marble begins to dissolve in the acid with effervescence, bubbles of gas coming off. This gas is carbonic acid gas, which in combination with lime forms chalk and marble.



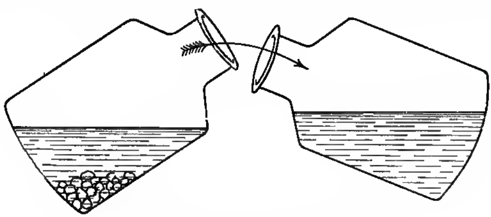
MAKING CARBONIC ACID GAS

After the acid has been acting on the marble for a few minutes, lower a lighted taper into the bottle.

The taper at once goes out, carbonic acid gas being inimical both to combustion and to life.

Experiment 30

Take some lime, shake it up with water. A little will dissolve. Filter the solution and keep in a corked bottle. Pour some of this clear solution or 'lime-water' into the bottom of another wide-mouthed bottle. Now take up the first wide-mouthed bottle which is full of carbonic acid gas, and go through the action of pouring from this bottle into the second, taking care not to tip it so far as to let any of the hydrochloric acid pour over.



POURING CARBONIC ACID GAS

The carbonic acid gas is a very heavy gas, much heavier than air, and so it pours over from the one bottle into the other. Now put your hand over the mouth of the second bottle and shake up the lime-water and carbonic acid gas together. A white precipitate of chalk or *carbonate of lime* is at once formed, the carbonic acid and the lime combining together, and the chalk being thrown down as it is insoluble in water.

We have thus shown that carbonic acid gas

(1) *Puts out a light.*

(2) *Is a heavy gas.*

(3) *Throws down a precipitate with lime-water.*

Experiment 31

Now, in the same way, pour hydrochloric acid on chalk, whiting, and washing-soda, and notice that in each case the same gas, having the same properties, is set free.

Experiment 32

Place some dry white lead in a bottle and pour on a little *nitric acid* this time (this is done merely because lead is more soluble in nitric than hydrochloric acid), and test the gas bubbling off. This gas will also prove to be carbonic acid, and *if the sample of white lead is pure it will completely dissolve in the nitric acid.*

We thus see that white lead is evidently a carbonate of lead and contains carbonic acid gas.

Now we can understand how it is prepared.

Experiment 33

Take a little lead which has been 'granulated' by melting the lead and pouring it into water.

Boil up a little of this granulated lead with *acetic acid.* It will slowly dissolve, forming a solution of 'lead acetate' or 'sugar of lead,' *the most dangerous of all dryers.*

Add to this solution a solution of washing-soda which we have seen contains carbonic acid. A white precipitate of *carbonate* of *lead* comes down which we can filter, wash with water and dry.

This is one variety of **white lead.**

We have now seen that to make white lead we must first attack and dissolve the lead with acetic acid, and then act on that with carbonic acid gas, and the result is white lead.

I can now explain the *best way* of doing this, which is very interesting, being a process of unknown antiquity, which has been very slightly modified.

The lead is first cast into gratings and the gratings are arranged over a lot of little pots containing acetic acid (in the old days vinegar was used), so that the vapour of the acetic acid can attack the metallic lead, to form lead acetates. The pots and gratings are next packed round with spent tan from the tanyard. This spent tan slowly ferments, and in fermenting gives off carbonic acid gas, which acting on the lead acetates converts them into lead carbonate.

After some weeks the 'stack' consisting of the piled-up pots and gratings is unpacked and the lead grids are found to have been changed into masses of lead carbonate; this also contains a certain amount of a compound of lead, oxygen, and water (lead hydrate) which improves its qualities.

The lead carbonate made in this gradual way is found to be of the best possible quality, being dense, of good covering power, and forming very durable coatings when painted outside and exposed to the weather. This process is known as the stack or Dutch process.

There are other ways of making white lead, besides that described in Experiment 33, but they are none of them so good.

White lead differs considerably in brilliancy and colour, the white lead made for house-painters not being nearly so white as the 'flake white' prepared for artists. This flake white is made from a specially pure lead, and the finest quality comes from Austria, and is known as Cremnitz white.

Experiment 34

Take two or three samples of dry white lead, and press them flat side by side with a spatula on a white plate and compare the whites one with another, for brilliancy and colour.

White lead even of the finest quality is a little yellow in colour, and it is consequently a common practice to add a very little ultramarine (about 1 part in 10,000) to neutralise the yellow. A better plan, however, which is used by some artists' colourmen, is, to add a little oxide of zinc which is a white of a *bluish* tinge. In this way the yellow tint of the white is removed without diminishing the brilliancy of the pigment.

When white lead is ground in oil it forms a peculiarly stiff firm mixture, quite different from that obtained by mixing ordinary pigments with oil.

This is best seen by examining a sample of white lead ground in oil by machinery, as it is sold for house-painting purposes. The peculiar consistency is supposed to be due to the fact that a little of the oil combines with the white lead to form a *lead soap*. (Ordinary soap is made by combining an oil or fat with soda, a lead soap is formed by combining white lead with an oil or fat.)

To the formation of this lead soap is attributed the tough leathery coating formed by white lead and oil when it dries.

The covering power of white lead, that is, the quantity of the paint necessary to cover completely a given surface, is of great importance to house-painters, but does not matter so much to artists.

There is only one way of testing accurately the covering power of a pigment, and that is to paint a surface over with black and white checks, and then see how many coats of paint, and what weight of paint, are required to paint out these checks when the paint is laid on by a skilled house-painter.

Any other methods are delusive, though we can get a rough notion by merely grinding the pigment in oil, rubbing it out with the finger, and noticing how far it covers with colour the surface underneath.

For covering large surfaces and preparing grounds the best quality of white lead prepared for house-painters is quite as good as the artist's flake white, the only advantage of the flake white being its greater whiteness and brilliancy.

Experiment 35

Rub out some white lead ground in oil on a piece of glass and put it aside to dry.

When dry expose it to sulphuretted hydrogen gas as described in Experiment 9. It will at once turn dark brown. Now place it in the window and examine it from day to day. It will gradually bleach in the bright daylight.

We learn by this experiment one of the great defects of white lead, its sensitiveness to sulphur gases. This makes it a somewhat unsuitable pigment for modern pictures which are exposed to the action of various sulphur compounds derived from coal gas, coal fires, sewer gas, and other sources, in large cities.

On the other hand, a picture which has been darkened in this way can be to a great extent restored by placing it in the window and exposing it to bright daylight.

White lead is no longer used for water-colour painting, and is gradually being given up for oil-painting.

Though oil-paintings which have been so discoloured can be restored by exposing to daylight, this cannot be done in the case of permanent decorative work on walls.

White lead should therefore never be used for paintings on the walls of buildings in cities.

It may be used, however, in country buildings, where there is no gas and no polluted air.

When an old water-colour painted with white lead has got discoloured, it may be restored by soaking blotting-paper in *peroxide of hydrogen*, and then pressing the damp paper on the surface of the picture. The peroxide of hydrogen at once bleaches the white lead.

White lead has one very serious defect, it is a deadly poison. Artists using comparatively small quantities do not suffer from this, but those who manufacture the white lead are constantly the victims of lead-poisoning. The replacement of this pigment by non-poisonous whites would therefore prevent a great deal of human suffering, and it is to be hoped that the time when the manufacture of white lead will be abandoned is not far distant.

White lead is often adulterated for house-painters' purposes with **barytes**. This is a white mineral (sulphate of barium) which forms a pigment of poor covering power, but absolutely permanent.

It is sometimes sold as permanent white.

Experiment 36

Grind a little barytes in oil, rub out, and notice the poor covering power.

Its presence in white lead can easily be detected if the white lead has been freed from oil.

It is insoluble in acids, and therefore is left behind in dissolving white lead in nitric acid.

Experiment 37

Mix a little dry white lead and barytes together and treat with dilute nitric acid. The white lead quickly dissolves and leaves the barytes behind. To prove this, after effervescence has ceased, pour the whole into a filter paper, wash the precipitate with water (this is done by filling up the filter paper with water, letting it drain *completely* away, and filling up again three or four times), then moisten the precipitate with sulphide of ammonium. It does not turn black, showing that the white lead has all been dissolved.

Zinc White

This is a very important white pigment for artists as it *is not affected by sulphur compounds.*

Experiment 38

Take some zinc white, mix it with water, and add ammonium sulphide.

It does not change colour.

Experiment 39

Compare the colour of zinc white with flake white both dry and in oil, and note the blue shade of the zinc white.

Zinc white is obtained by burning zinc, and is a *zinc oxide.* As manufactured it is poor in covering power, but by grinding under heavy edge runners a *condensed zinc white* is produced equal in covering power to the best white lead.

Experiment 40

Compare ordinary zinc white, condensed zinc white, and white lead ground in oil, by rubbing out, and notice difference of covering power.

Zinc white is now used for water-colour painting under the name of **Chinese white.**

SULPHATE OF LEAD

Experiment 41

Dissolve *lead acetate* in water and add a little dilute *sulphuric acid* instead of washing-soda as before (*Experiment* 33); a white precipitate is thrown down.

Filter, wash, and dry.

This is lead sulphate which is now being used in the preparation of white pigments.

Grind a little in oil and note the colour and covering power.

Lead sulphate prepared in this way is poor in covering power. It is therefore either prepared by subliming lead ore or by grinding the precipitated lead sulphate with zinc oxide under heavy edge runners.

The last process gives the best pigment. It is a pure white, a little blue in colour and covering as well as white lead.

It is *much less susceptible* to sulphur compounds than white lead, and is practically insoluble in acids.

Experiment 42

Grind a little lead sulphate in oil, allow it to dry and expose to sulphuretted hydrogen, as was done with white lead.

Note the slight change produced.

Warm lead sulphate with dilute nitric acid. It is almost insoluble.

And for this reason it is very slightly poisonous, those manufacturing it not suffering from lead-poisoning.

These zinc oxide and lead sulphate paints are now being brought before house-painters and artists under various names, such as 'White Lead, Caledonia Park Works, Glasgow,' 'Freeman's White,' 'the New Flake White or Cambridge White,' 'Marble White,' etc.

They have the advantage of keeping their colour better in the impure air of large towns and gas-lighted rooms, but whether they will stand exposure out of doors as well as white lead is not yet ascertained.

Zinc white prepared the old way was believed by artists to flake off, but these new whites have shown no such tendency. They are also practically non-poisonous, and free from the disagreeable smell of white lead.

CHAPTER VIII

SOME IMPORTANT ARTIFICIAL YELLOWS

A LARGE number of the bright yellows are unfortunately fugitive, and there are only a few, therefore, which we need consider here.

CHROME YELLOWS

In the first place, the chrome yellows of various kinds must be considered, their preparation, and how far they can safely be used.

Experiment 43

Prepare a solution of *barium chloride* and of potassium chromate, and add the one solution to the other. A yellow precipitate of *barium chromate* or LEMON YELLOW is thrown down. Wash the precipitate, dry, and expose a wash to light.

It will be found to be **permanent**, and is therefore a safe pigment for artists to use.

Unfortunately similar lemon yellows can be prepared from salts of strontium and of lead which are not so durable. Of these the lead lemon yellow is the cheapest.

Experiment 44

Dissolve some *lead acetate, sodium sulphate,* and *potassium bichromate* in water and mix them all together. A yellow precipitate is thrown down, which is a mixture of the white *lead sulphate* with the yellow *lead chromate.*

Wash, dry, and expose the pigment ground in oil to the action of sulphuretted hydrogen. It at once *blackens,* while barium chromate when tested in the same way does not alter.

This shows clearly the unsuitability of LEAD CHROMATES for artists' purposes. Every shade of *lead chromate* from bright scarlet to pale yellow can be prepared, but should all be avoided except for common house-painting purposes. They are known as CHROME YELLOW, ORANGE, etc.

Mixed with Prussian blue, lead chromate is used for making 'CHROME GREENS,' and other cheap greens appearing under a variety of names. None of these is permanent.

So BARIUM CHROMATE is the only *chrome* colour artists should use.

The most important group of yellows are the

CADMIUM YELLOWS

These may be prepared of various shades and by various processes.

There is, however, one simple process by which, with little trouble, we can prepare several of these shades for ourselves.

Experiment 45

Dissolve 1 ounce of cadmium sulphate in water and add to it 1 ounce of *sodium hyposulphite.* Place over a lamp and boil gently.

Gradually a *pale yellow* cadmium yellow will come down.

After about one hour's boiling filter off the pale yellow precipitate, add 1 ounce of hyposulphite and continue boiling. Gradually an orange yellow will come down. After an hour filter off and boil again. A deeper orange shade will now separate.

Wash and dry these three precipitates and expose to light.

The pale shade will fade, but the more orange shades will not change.

This was supposed to be due originally to the presence of free sulphur in the pale shades, but this is not so, and the fading of these pale shades seems to be due to two varieties of cadmium sulphide.

The practical result is that only orange shades of ordinary cadmium yellows should be used.

There are two pale cadmiums in the market, however, both made by a secret process, viz. Winsor and Newton's Aurora Yellow, and Madderton & Co.'s Daffodil, which are quite permanent.

Cobalt Yellow (Aureoline)

This yellow is made by a somewhat complicated process. It is permanent, and may be safely used. I shall not trouble you with the details of the manufacture here.

Naples Yellow

Formerly a compound of lead and antimony, now a mixed yellow.

If made from proper ingredients, quite permanent.

This practically exhausts the list of bright yellows, the yellow lakes, such as DUTCH PINK and ITALIAN PINK, being very fugitive, and GAMBOGE and INDIAN YELLOW not being sufficiently permanent.

The student should satisfy himself, however, on these points by making washes of all these pigments and exposing them to light.

Dutch and Italian Pink are prepared from Quercitron Bark, some Yellow Lakes from Persian Berries, and Indian Yellow from Purree.

CHAPTER IX

SOME IMPORTANT ARTIFICIAL REDS

LET us first examine VERMILION. This magnificent pigment has been prepared artificially for at least five hundred years in Europe, and probably for a very much longer time in China.

The old, and present Chinese, method is to sublime sulphur and mercury together, the *red sulphide of mercury* subliming and collecting in the top of the crucible cover.

This is then subjected to grinding, floating over and washing.

The modern method is to prepare a *black sulphide* of *mercury*, and then by heating with a strong *alkali*, like *caustic potash*, to convert it into the red variety.

Vermilions prepared the modern way are not so pure chemically, sometimes contain injurious quantities of alkali and sulphur combinations, and are apparently not so permanent.

It is safer, therefore, to use real Chinese vermilion in painting.

While vermilion seems to last for an unlimited period in ordinary rooms and galleries, it is injuriously affected by sunlight after some time.

Experiment 46

Paint out a wash of vermilion and expose to sunlight. After a time portions will be found to *turn black.*

Its durability, however, on old pictures seems to justify its use. The change of colour mentioned above is not due to air or moisture, but is simply due to the red variety of the sulphide turning into the black variety, and it seems to require the action of *sunlight for some time* to bring it about.

The Madder Lakes

Experiment 47

Dissolve a little *alizarine* in *ammonia* (alizarine is the dyeing principle of the madder root, and is now artificially prepared from coal-tar), and add a solution of alum.

A ruby red precipitate is thrown down and the violet colour of the liquid disappears. Compare this with the white precipitate obtained on adding alum to the ammonia without the alizarine.

Wash and dry both precipitates and grind them in oil.

The alum and ammonia *alone* give a precipitate of *alumina,* the *base* on which the *lake* is *struck.*

When alizarine is present, it dyes the alumina as it is coming down, thus giving it a ruby red colour.

The alumina *alone* in oil gives a transparent, colourless jelly.

The dyed alumina a ruby-coloured lake.

Experiment 48

Repeat the last experiment, only before adding the alum, put into it a drop or two of a solution of green vitriol (sulphate of iron).

The lake thrown down will now be purple in colour.

To another portion of alum add a drop or two of blue vitriol (sulphate of copper). The lake thrown down will now be brownish purple in colour.

In this way we see how different coloured lakes can be obtained from alizarine and alumina.

It is a matter of no moment whether the alizarine used be made by extracting it from the madder root or by an artificial process.

Experiment 49

Expose to light washes of madder lakes.

They will prove remarkably permanent, the purple and rose madders showing slight changes, and the strong ruby reds showing no change at all.

If madders alter or fade it is probably because some other dye, like cochineal, has been added to obtain a particular shade of colour.

Cochineal Lakes

These lakes are prepared with alum and the colouring matter of the *cochineal insect*, and are sold as Crimson Lake, Purple Lake, Scarlet Lake, and Carmine.

They are all fugitive, and should not be used. The student should expose a wash of crimson lake, if he has not yet done so, and note change of colour and fading.

Avoid all lakes except madder or alizarine lakes.

CHAPTER X

SOME IMPORTANT ARTIFICIAL BLUES

Experiment 50

Prussian Blue

Dissolve *sulphate of iron* in water, and add a few drops of *nitric acid*, and warm.

Dissolve *potassium ferrocyanide* in water.

Mix the two solutions.

A precipitate of *Prussian blue* is at once thrown down.

This pigment is fairly permanent and may be used in oil, but in water-colour its use is somewhat doubtful.

On exposure to sunlight it becomes greener, and slowly fades, but on being placed in the dark the colour gradually comes back again.

Wash out some of the colour and notice these changes.

Cobalt Blue

This pigment, which owes its colour to the metal cobalt, can be prepared as follows :—

Experiment 51

Moisten some dry *alumina* with *cobalt nitrate* and heat strongly on charcoal in a blowpipe flame.

A bright blue powder is the result.

The manufacture of cobalt blue is a government monopoly in Germany.

BLOWPIPE

The pigment is **absolutely permanent.**

Paint out a wash of the colour, and observe the effect of light upon it.

Cerulean Blue

This pigment is closely allied to cobalt blue, and is **absolutely permanent.**

Both these pigments are expensive, and therefore *cheap* tubes of colour claiming to be cobalt blue or cerulean blue should not be used.

Ultramarine

This pigment used to be extracted from *lapis lazuli*, and real ultramarine so prepared can be obtained at a very high price. It has, however, been replaced by 'artificial ultramarine.'

This substance is almost exactly the same in chemical composition, and though Mr. Holman Hunt has thrown doubt on its durability, the results of other tests show that if of good quality it is QUITE PERMANENT.

It is prepared by heating together *soda*, *China clay*, *sulphur*, and *resin*, under special conditions.

Experiment 52

The student should paint out a wash of the colour and note the effect of light upon it.

INDIGO

This blue, obtained from the indigo plant, is of great beauty for water-colour work, but unfortunately very fugitive.

Experiment 53

Paint out a wash of indigo blue and note the result.

CHAPTER XI

SOME IMPORTANT ARTIFICIAL GREENS

ONE group of greens, the Chrome Greens, I have already dealt with: they are mixtures of chrome yellow and Prussian blue, and are not permanent. They must not be confused with **oxide of chromium greens.**

There are two greens which are the oxides of the metal *chromium*, one the simple oxide, sold as 'OXIDE OF CHROMIUM,' the other the compound of the oxide with water, sold sometimes as OXIDE OF CHROMIUM and sometimes as VIRIDIAN.

The first is a pale opaque, and the other a blue transparent green.

Experiment 54

Heat gently some *bichromate of potash* and *boracic acid* on charcoal. Take the dark green fused mass and grind and wash. The residue is viridian.

On heating more strongly the pale opaque variety will also be obtained.

Both these greens are **absolutely permanent and do not affect other colours injuriously.**

Expose a wash of each to light and note the result.

Cobalt Green

There are several cobalt greens, from pale opaque to bluish green transparent varieties.

They are **absolutely permanent and do not affect other colours injuriously.**

Experiment 55

Prepare a wash of cobalt green, expose to light and note the effect.

Emerald Green

This green is a compound of *copper* and *arsenic*, and is thrown down on adding a solution of *white arsenic* in *carbonate of soda* to *copper sulphate*, and then treating the precipitate with dilute *acetic acid.*

It is the most brilliant of all artificial greens and is very poisonous.

It is **permanent,** but *injuriously affects vermilion and cadmium yellow*, and even if glazed over, these pigments in oil will slowly penetrate through the oil and destroy them.

Probably an intervening coat of a spirit varnish would stop this.

Experiment 56

Mix emerald green and cadmium yellow, both ground in oil together, and keep to note the effect.

Next expose a wash of emerald green to light and note the effect.

VERDIGRIS

This lovely green was largely used by the 'old masters.' It must not be mixed with water or oil, as it gradually turns black, and is also susceptible to sulphuretted hydrogen, and attacks other pigments.

It can, however, be used for decorative purposes dissolved or ground in a spirit or turpentine varnish, and produces a very rich effect glazed over white or tinted surfaces.

CHAPTER XII

SOME IMPORTANT ARTIFICIAL BLACKS

Bone or Ivory Black

This is prepared by heating bones or ivory in a retort, and is a fine and absolutely permanent black.

Lamp Black

This black is not much used by artists, and was regarded with great suspicion by the sixteenth-century Italian painters. It is prepared by burning oil in a confined space, and collecting the black particles. Its principal use is for making printing ink.

Vine Black

This should be the charcoal of vine twigs or peach stones. It has then a fine blue shade.

If made from common charcoal it is often tinted with indigo, a *most pernicious practice.*

Other shades of **charcoal black** are also prepared from different woods, and from wine lees, etc. etc.

Experiment 57

Heat a little indigo in a test-tube and note the purple vapour. In this way the presence of indigo in vine blacks can be detected.

All these pure blacks are permanent and do not affect other colours.

CHAPTER XIII

OILS

Experiment 58

TAKE some linseed and crush it in a mortar. Place the crushed seed in a bottle with some light *petroleum spirit.* Shake it up and let it stand for some hours, then pour off the petroleum through a filter into a flask, and place the flask in boiling water. The petroleum soon boils off and leaves the oil which it has dissolved out of the seed behind. **This is linseed oil.**

In the same way a small sample of **nut oil** from walnuts, and of **poppy oil** from poppy seeds, can be prepared.

On a large scale these oils are prepared by exposing the seeds to tremendous pressure after they have been ground, the oil being thus squeezed out.

LINSEED OIL

This oil is of the finest quality when it is pressed from the cold seed. It is then of a deep golden yellow colour. The common quality pressed from hot seed is of a brownish tinge.

The oil after extraction is still far from pure, containing various impurities which have been squeezed out from the seed along with the oil.

These impurities are best removed if the oil is to be used for artists' purposes in the following way:—

Experiment 59

Take a clean glass bottle, put some sand in it, and then fill one-third of the bottle with salt water and one-third with the linseed oil to be refined.

Cork the bottle, shake up the contents thoroughly, loosen the cork so that air can get in, and place the bottle outside on the ledge of a sunny window.

Every morning for a week shake up the contents of the bottle vigorously.

Gradually a white flocculent substance separates from the oil and is dragged out partly by the sand. After one week of this vigorous shaking leave the bottle alone on the window-sill for five or six weeks.

At the end of that time the salt water will be full of a flocculent precipitate, and the oil above will be clear and of a pale golden colour.

Now draw the oil carefully off by means of a siphon made of a piece of tin gas tubing, or a piece of glass tubing, bent into a suitable shape by warming the glass in an ordinary gas flame, and filter the oil through a filter paper. (The coarse grey filter papers are best for this.)

The oil is now ready for use, being refined raw oil.

The bleaching may, however, be carried further, the oil ultimately becoming almost colourless.

Nut oil and poppy oil can be refined in the same way, but do not require bleaching, as they are nearly colourless oils to start with.

Raw oil is used to grind colours with, some colourmen using linseed oil for all their colours, some preferring nut oil or poppy oil, especially for delicate blues and whites.

It must be remembered, however, that *all oils* yellow with time on a picture.

In order to get the colours of a nice consistency when being ground in oil, a little *alumina* (see preparation of lakes) may be added along with the pigment to the oil. This will give a stiff crisp mass, neither treacly nor sticky.

Other substances are also used for this purpose, but alumina is perfectly harmless, and is therefore, if pure, very suitable for stiffening the colours.

Raw oil, though best for grinding most colours, 'dries' very slowly.

It is therefore often necessary to use as a medium an oil which will dry faster.

For this purpose a 'boiled oil' is prepared.

Experiment 60

Place some refined raw linseed oil in two little glass flasks, add a little red lead to the one flask and a little *borate of manganese* to the other.

Keep them very gently boiling over a lamp for four or five hours.

Take a clean glass plate and put on it a drop of raw oil, a drop of the oil boiled with red lead, and a drop of the oil boiled with *borate of manganese.* Rub out each drop with the finger, put the plate away, and examine from time to time. The two boiled oils will 'dry' quickly, while the raw oil will remain liquid.

This 'drying,' as it is called, is really due to the oil being oxidised into a resinous substance, and is a process peculiar to certain oils called for this reason drying oils.

In course of time the drop of raw oil will also 'dry,' while a drop of olive oil under the same circumstances will never dry.

Both these boiled oils evidently are now quick drying oils, but the one has a great advantage over the other, as can be shown by the following experiment.

Experiment 61

Expose the glass plate with the dried patches of oil to sulphuretted hydrogen gas. The oil boiled with red lead at once darkens, because the oil has dissolved some of the lead, while the oil boiled with manganese borate shows no change.

For artists' purposes, therefore, only oils boiled with some compound of manganese should be used. Several compounds of manganese may be used for this purpose, and you will remember that umber, which contains manganese, acts as a dryer.

In many old MSS. *sulphate of zinc* is recommended as a dryer. It really has very little or no effect, but there is reason to believe the sulphate of zinc formerly used was an impure variety containing manganese, so that manganese dryers, far from being a modern discovery, probably date back to the fifteenth century at least.

Drying oils form a resinous coating which, when first formed, is tough and elastic, but in course of time gradually grows hard and brittle, so that *ultimately* an oil picture becomes very fragile and easily destroyed.

It has the advantage of forming a transparent medium which is easily manipulated, and at the same time *partially* protects the pigments from the action of air, moisture, and injurious gases.

That it is penetrable by gases our earlier experiments with sulphuretted hydrogen have shown us.

CHAPTER XIV

VARNISHES

VARNISHES are prepared from gum resins which exude from certain trees, and come from various parts of the world.

Of these, the most important to artists are—

Amber.—A fossil resin found in the Black Sea and other places. This is the hardest of all the resins, and the most difficult to fuse. It is supposed to give the most durable varnishes.

Copal.—This is also a fossil resin, and is found in certain parts of Africa. It is exported as Sierra Leone or Zanzibar copal. Other so-called copals are softer and inferior resins.

Sandarac.—This name was originally applied to the resin of the juniper. It is now applied to the resin obtained from a coniferous plant found in Algiers. It is soft, easily dissolved, and forms useful varnishes.

Mastic.—This resin is obtained from a small tree (*Pistacia lentiscus*) found in the Greek Archipelago. It is a *very soft* resin, and dissolves easily in turps or spirits of wine.

Venice turpentine.—This is a balsam or liquid resin obtained from the larch.

Canada balsam.—This substance, which is practically the same in its properties as Venice turpentine, is obtained from a similar tree in America.

Oleo de Abezzo.—This is the balsam of the silver pine. It was formerly largely used for preparing varnishes, and is repeatedly mentioned in old Italian receipts. It is not now an article of commerce.

Dragon's blood.—This resin is of a deep red colour. The best quality is in sticks tied up in fibre. The inferior quality is sold in lumps.

Aloes.—This is of a dark brown colour.

Gamboge.—This is of a bright yellow colour.

Varnishes

Varnishes can be divided into two groups, *oil varnishes*, and *spirit* or *turpentine varnishes.*

Oil varnishes are made by dissolving a *resin* in *oil.*

Spirit varnishes are made by dissolving a *resin* in *spirits of wine*, and *turpentine varnishes* by dissolving a *resin in turpentine.*

In the case of spirits of wine and turpentine the solvent more or less completely evaporates and leaves a skin of the resin behind.

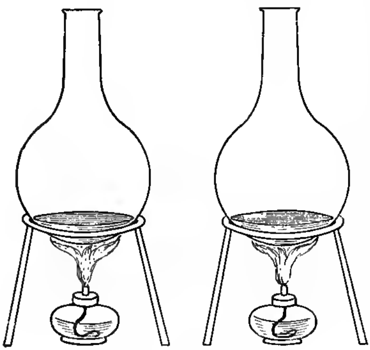
In the case of oil varnishes, the oil 'dries,' forming a skin composed partly of oil and partly of resin.

Experiment 62

Take two small round-bottomed hard glass flasks. Put a little boiled oil in one and heat it over a flame.

When the oil is hot, put some powdered copal in the second flask and heat it strongly over a flame till all the copal is melted. Then begin to add the hot oil little by little, stirring vigorously by swinging the flask (it can be held with a piece of cloth round the neck).

When about three times as much oil has been added in volume as there is copal, place the flask back over the flame and heat it again. Dip in a glass rod into the varnish from time to time and put the drop removed on a glass plate.



MAKING VARNISH

At first the drop on touching the glass plate will quickly turn milky in appearance, but after the heating has been continued for a short time, the drop on cooling will remain clear.

The varnish is now finished, remove it from the flame, let it cool a few minutes, and add little by little, with vigorous shaking, about an equal volume of turps. Filter through a piece of muslin into a bottle.

If this operation has been successfully performed a light-coloured clear varnish is obtained, which, though doubtless improved by keeping, will, if used at once, dry into a hard transparent glossy surface.

Amber varnish can be prepared in the same way, but is rather dark in colour.

Many receipts have been given for preparing a light-coloured amber varnish, but I only know one which is successful.

With all the others, either little or no amber is dissolved, or the solution obtained is dark.

The one successful method is to dissolve the amber (finely powdered) in chloroform, and then add turps carefully to this solution and a little oil, then place in a flask and distil off the chloroform, leaving the amber dissolved in the turps and oil.

There is, however, no reason to believe that a varnish prepared with hard Sierra Leone copal is not as good as amber varnish.

There are other so-called copals which are of little value, the student should therefore notice the appearance of the genuine article. Oil varnishes of the other resins can be prepared in the same way.

Spirit or turpentine varnishes can be formed by putting the powdered resin in a flask, covering it with turps or spirits of wine, fitting a cork *loosely* to the neck and placing the flask in boiling water. The resin will gradually dissolve, if it is soluble in these substances.

Sandarac and mastic can both be dissolved in this way.

Experiment 63

Take of powdered mastic 7 ounces, of Canada balsam 1 ounce, of turps 22 ounces, and warm them gently together by placing the flask in boiling water. When the mastic is completely dissolved place a loose plug of cotton wool in the bottom of a glass funnel, and rapidly filter the varnish into a clear dry bottle, cork and keep for use.

This is the best varnish for finished pictures, simply because it is *very easily removed.* When dry, rubbing with the palm of the hand or a little spirits of wine and cotton wool will remove it.

Consequently a picture varnished with it is easily cleaned *without injury to the picture underneath.*

This is impossible if an oil varnish has been used.

Never varnish a picture till at least six months after painting it.

Shellac dissolved in spirits of wine makes a nice varnish for leather and general purposes of that kind, and if gum lac be used, which is the crude shellac, a fine red varnish is obtained. Sometimes *coloured varnishes* are required for decorative purposes.

For these, aloe gum gives a nice brown, and dragon's blood a fine red, while gamboge gives a beautiful yellow.

To prepare them, put some Canada balsam, or 'Venice turpentine' in a round-bottomed flask, heat, and then add the powdered aloes, dragon's blood, or gamboge, in the required quantity. They will dissolve in the melted turpentine or balsam.

Next add some powdered sandarac. This will also dissolve readily. The weight of sandarac should be roughly equal to the weight of balsam. Then remove the flask from the lamp and dilute with turps. If this is too brittle a varnish for the purpose required, a little boiled oil must be added and thoroughly incorporated by heating with the other ingredients.

A beautiful green varnish is obtained by dissolving verdigris in 'Venice turpentine.'

Coloured varnishes are now made by dissolving aniline dyes in the varnish. I cannot speak, however, as to their durability, not having tried them, and the colouring matters

I have described have the merit of antiquity, being taken from old receipts. At the same time, very little, if any, boiled oil should be added, as the addition of oil means a more or less porous medium, and the colours are no longer so well protected from moisture.

Verdigris, for instance, is permanent in Venice turpentine alone, but fugitive in oil alone.

I have already said that mastic in turps is best for varnishing pictures. Copal in oil is a very durable varnish, and may be used with advantage as a medium, or for varnishing some surface which requires a very durable elastic coating. But as already explained, its durable qualities are the very reason why it should not be used for varnishing pictures, as when dirty it is so difficult to remove that the picture is almost certain to be injured in the process.

Wax

Sometimes, in preparing a special medium, beeswax or paraffin wax is used.

Either of these substances has the property of making the colour they are mixed with dry *dead.*

Consequently they are of use when oil colours are used for wall decoration, and where a dead surface is required.

I describe elsewhere how such mediums are used, but I shall say here a word or two about their preparation. One of the best known is **M. Gambier Parry's medium.**

Professor Church thus describes its preparation. Warm 8 ounces of oil of spike in a flask to 80° C., then add 2 ounces of 'gum elemi.' Filter. Pour on the filter 2 fluid ounces of turpentine heated to 80° C., and mix the two filtrates.

Heat the mixed liquids, melt 4 ounces of white wax and pour into the liquid in a thin stream. When the mixture is complete, add gradually 16 ounces of oil copal varnish with vigorous shaking.

This medium can be used to grind the colours in, and thinned down with turps to paint with.

Professor Church also describes another medium of his own devising.

4 ounces of paraffin wax are dissolved in 12 fluid ounces of turpentine. Heat till paraffin is thoroughly dissolved; then add 16 fluid ounces of oil copal varnish and warm and shake till thoroughly incorporated.

This medium has the advantage over the other of being simpler to prepare and not containing the gum elemi, which is a doubtful ingredient at the best.

On the other hand, the paraffin wax has a bad habit of crystallising out from the mixture instead of remaining blended with it, as beeswax does.

In my opinion the *best medium* for wall-painting is Professor Church's medium with beeswax instead of paraffin wax.

Diluting Mediums

Three are used by artists.

Turpentine, Oil of Spike, Petroleum

Of these, petroleum is probably the safest as it evaporates *clean* and leaves no resinous deposit if it has been *properly rectified.* To test this, moisten a piece of writing-paper with it and then expose it to the air.

The petroleum should evaporate *without leaving any greasy stain.* There is, however, no serious objection to the use of turpentine or oil of spike.

Turpentine is obtained by distilling the fluid balsam obtained from the pine.

PART II

NOTES ON 'PROCESS,' AND ON TEMPERA, FRESCO, WATER-COLOUR, AND OIL-PAINTING

CHAPTER XV

DRAWING FOR PROCESS

PHOTOGRAPHIC methods of reproduction are now being so largely used in place of woodcuts, or engravings on copper and steel, that it seemed of importance in a work of this kind to say something about the actual processes used in reproduction, in order that those engaged in drawing for 'process' should understand something of what is done with their work, and what the limitations of the different methods are. In this way it is to be hoped an artist will be able to work more intelligently for the photographer, and consequently obtain more satisfactory results. To treat of etching, or engraving on copper and steel, would be impossible in a little book like this, but a good deal of useful information can be given for those who are drawing for 'process.'

There are several leading methods of photographic reproduction and innumerable modifications of these, almost every firm engaged in this class of work having its special methods, usually dignified by a special name. To deal with all these is, of course, impossible, but some of the leading methods can be described, with a view to assist and guide the artist through the maze of slightly differing processes employed.

In the first place, we may begin by briefly pointing out the different stages by which an ordinary photograph is produced, with a view to making clear, further on, the methods of photographic reproduction. On visiting a photographer 'to have a likeness taken,' one is placed before the camera. In the front of the camera is an arrangement of lenses, by which an image of the sitter is thrown on the back of the camera, and placed in the back of the camera is a glass plate, covered with a thin coating of a preparation which is sensitive to light. After the image of the sitter has been allowed to fall for a brief period of time on the sensitive plate, the plate is removed to the 'dark room,' and treated with a 'developing solution.' The result of treatment with this solution is to bring out the image of the sitter on the sensitive plate, but an image in which all the lights and shadows are reversed. For where the lights fell on the plate, there the sensitive surface was most affected; and where the shadows fell on the plate, there the surface was least affected.

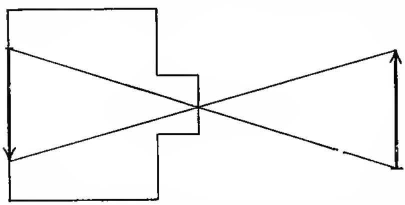


DIAGRAM OF CAMERA AND OBJECT

If, after the glass plate with its film has been put through another process, known as 'fixing,' we hold it up to the light, we find the image of the object photographed upon the surface, the shadows of the original object being represented by clear glass, and the lights of the original object by dark opaque portions. This glass plate with the image upon it is known as the 'negative.'

In order to obtain a 'print' from this negative, a piece of paper, coated with material sensitive to light, is placed under it, and the whole exposed to the sun. In a short time the light passing through the negative stamps the image on the sensitive paper. But now the lights and shadows are arranged as they were in the original object, the paper being darkened where the light passed through most easily; that is, where it passed through the clear glass portions of the negative, and remaining light in colour where the light was stopped by the opaque dark portions of the negative. In this way a picture or any number of pictures of the original object can be produced by putting one piece of paper coated with sensitive material after another under the negative and exposing to light. Thus the photographer produces the ordinary 'prints' which are mounted and sold. If he wished to reproduce a black-and-white drawing he would do so in the same way, by placing it before the camera, obtaining a negative of it, and then 'printing' off copies in the way described.

This, however, would be a tedious and expensive method of going to work, and consequently much ingenuity has been spent in devising methods whereby the action of the light can be made use of to obtain an engraved block of the original drawing which can be placed in the printing press, and used to reproduce the drawing over and over again. It was also necessary to devise a process which could produce an impression of such a character that it could be set up and printed off along with ordinary type.

There are many different methods of obtaining this result, but a very large number of them are based upon a peculiar property of a film of gelatine, or albumen, or bitumen, when exposed to light under certain conditions. For instance, it has been found that if a film of gelatine is first steeped in a solution of 'bichromate of potash' and then exposed to light, it becomes insoluble in hot water. Similarly, albumen and bitumen properly prepared can be rendered insoluble. This fact is the basis of most reproductive processes, and we can now procced to the descrip-

PROCESS BLOCK. LINE WORK WITH NO HALF-TONES

tion of the production of a process block of a line-drawing, without any half-tones. The artist's drawing is illuminated, usually by an electric light, and placed outside a camera and a negative obtained, just as in ordinary portrait photography, with this difference, however, that usually a collodion plate is used instead of a gelatine plate. From this negative the next step in the process starts. If we examine this negative we shall find, as already explained, that the black lines of the original drawing are represented by clear glass on the negative, and the white paper by black opaque portions. This film is now stripped off and reversed. A film of albumen is laid over a zinc plate and rendered sensitive to light by means of bichromate of ammonia, and is then exposed to light under the negative. The result of this treatment is that all the parts of the negative which are transparent allow the light to pass freely through and render these portions of the albumen insoluble; while the dark opaque portions of the negative protect the albumen underneath and leave these portions soluble. Consequently the insoluble portions correspond to the black lines in the original drawing, and the soluble portions correspond to the white paper in the original drawing. This film of albumen is then washed with cold water, so as to wash away the soluble portions, leaving the other portions on the zinc plate. This zinc plate, after protecting with bitumen, is next put in a bath of acid and etched, the portions exposed by the removal of the albumen being eaten away, and the other portions protected by the insoluble albumen, and corresponding to the original lines on the artist's drawing, being left.

After several etchings the block is cleaned, and used like a wood-block for printing.

In this way a line-drawing is reproduced by 'process.'

In order to obtain satisfactory results from this method of reproduction, it is essential that the artist obey certain rules in doing his part of the work. In the first place, he must select a paper which is smooth and close-grained without any shine on the surface. Bristol board does very well. Then he must use a very black ink. One of the best inks for the purpose is Stephens' ebony wood stain,

DRAWING NEARLY ORIGINAL SIZE

which, though manufactured for a different purpose, is very largely used by black-and-white artists.

Then the drawing is usually considerably larger than the finished block is to be. Usually the block is not more than one-third of the size of the artist's drawing. This reduction in size must not, however, be pushed too far, as it results, unless the drawing is from a very skilful hand, in spoiling the final picture.

But it is above all things important that every line should be clear, definite, and black, and sharp in outline; that the artist, keeping in mind the fact that his drawing is going to be reduced, should not blur anything or put in any unnecessary lines, but should rather study the art of leaving out every line not absolutely essential for his purpose. His finished drawing should bear being looked at from some little distance, and should be done with a view to simple bold effects, without too much detail or minute work. The illustration shows a portion of an artist's drawing reproduced full size, while next to it is the whole drawing after reduction. By examining carefully these two illustrations, the beginner will learn more about how to draw for process, than can be learnt from mere verbal description.

Having now described in an elementary manner the reproduction of line work by process, the next thing to be mentioned, following a due order of increasing complexity, is 'stippling.' Sometimes the artist having completed a line-drawing wishes certain portions softened by a half-tone. He indicates this by shading them with a blue pencil. The photographer then introduces mechanically dots or lines to produce the half-tone required. This is sometimes effective in drawings where simple broad treatment is required, or in designs, as it enables the lines

SAME DRAWING REDUCED: PROCESS BLOCK WITH NO HALF-TONES to be deeply etched in, which cannot be done in the case of half-tone work, which, as will presently be explained, does not lend itself so readily to sharp contrasts of black and white. This stippling process leads us naturally to half-tone blocks and their method of production.

In order to produce half-tone it is necessary that the

STIPPLING KNOWN AS 'RESIN GRAINS' IN SKY

half-tones on the block be represented by minute dots or lines, which are larger or smaller as the half-tone is darker or lighter.

The conditions of printing will at once reveal this necessity. An ink roller is run over the block and then the paper pressed on it to take up the ink. Where there are portions in relief the ink remains and is transferred on to the paper. Where there are hollows the ink does not go, and the paper remains white. When dealing with a line-drawing, therefore, the whole matter is very simple, but half-tones require evidently some special treatment of the block to be reproduced on the printed page. In the case of etching, engraving, and woodcutting, the half-tones are obtained by the nearness or distance apart of minute lines, hatchings, or dots, and varying thickness of line.

In the same way, in preparing a process block for the printer, the half-tones must be represented by minute lines or dots, near together or far apart, according to the amount of shade or light required. The problem before the photographer is, how can this result be obtained from a drawing consisting of continuous gradations of tone? This problem has been solved in a most ingenious manner.

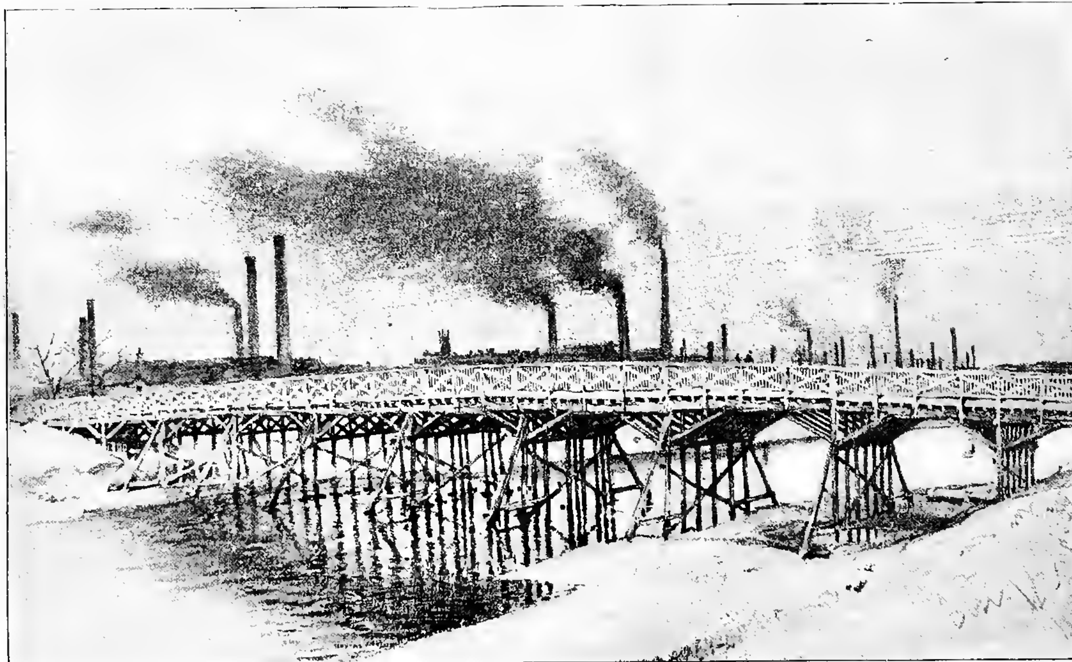
When the picture is placed before the camera there is interposed between it and the sensitive plate a fine screen of some kind, usually consisting of glass plates upon which fine lines have been ruled so as to produce a minute network. This breaks up the continuous tones of the picture into minute dots, giving varying opacity with varying size, and when the plate is afterwards etched it is eaten out into a fine pattern, leaving the plate, where etched deeply, covered with minute points of metal some distance apart; while, where not etched deeply, the little points of metal are broader and almost touch each other.

If the negative had been exposed under the screen to an uniform light, say from a sheet of white paper, the final print would have been a white to grey or black surface, quite uniform, and made up of little dots of ink. The amount of light in the grey would have varied according to the length of exposure. But by also placing before the negative the artist's drawing, some portions of the negative are protected from light more than others, and consequently on the zinc plate the gelatine is left on some portions to a greater extent than on others, and so retards the etching process.

If any half-tone process print is examined closely it at once resolves itself into a regular pattern, thus revealing the secret of its manufacture.

Now there are serious difficulties in this half-tone work which somewhat limit its capacities. If the etching is carried far the stability of these minute points of metal is endangered, and they are likely to be completely eaten away. The result is that the plate is very lightly bitten in, and the final surface is in very low relief, thus differing from line work, where the plate may be safely bitten in to a considerable depth, and requiring very careful printing.

Consequently, though remarkable results giving plenty of contrast have been obtained by careful working and printing, and delicate half-tones are also obtained, there is a great want of contrast, and there are no pure whites or deep blacks in the ordinary commercial work. The artist should therefore recognise the limitations of the process from the first, and not ask from it what it cannot do. The illustration shows a specimen of half-tone process work. The effect is pleasing though wanting in contrast, for the reasons already given. But the artist can do more. He can assist the process over its weak points by his treatment of the subject. Instead of having one tone gently passing into another, he should emphasise the difference between each tone employed in his drawing and exaggerate it. Especially should this be done in the tones next to black and next to white. A considerable gap should be left here which, while throwing his drawing out, as a picture, will tend to prevent too much flatness in the finished print.



HALF-TONE PROCESS BLOCK. NOTICE FINE GRAIN PRODUCED BY THE SCREEN

It is usual in doing half-tone work to first tint the paper over with a slight wash of neutral tint, then put in the drawing with the brush, using lamp black, which gives a nice grey, in preference to Indian ink, and using Chinese white, remembering to exaggerate the effects as described above. Care should also be taken that no portions dry shiny. As said before, *commercial* half-tone process work is very limited in its capacities, but it can be helped by the printer as well as by the artist. By carefully 'backing' certain portions the printer can vary the pressure of the paper on the block and obtain in that way greater variety of light and shade.

Where delicate gradations of tone are wanted, along with sharp contrast, it can only be obtained commercially by resorting to the wood block. Woodcutting alone produces a block which can be printed with ordinary type, and which at the same time gives the artist a wide range of treatment. Commercial process produces line work with great perfection, and within certain limitations, due to bad printing principally, produces very pleasing half-tone work, but the wood block must be resorted to for many effects. These two illustrations show the same drawing treated by process and by woodcutting, and bring out very clearly the defects of the process work. Of course, photography is now employed by the woodcutter. A photograph of the drawing is taken on the block of wood to guide him as to what to cut away and what to leave. We have then three methods of reproducing the artist's work in such a form that it can be printed off with ordinary type, namely:

Process blocks for line-drawings with or without stippling, as required by the artist.

Woodcuts. Process blocks for half-tone.

PROCESS BLOCK TOUCHED UP ON HIGH LIGHTS WITH A GRAVING TOOL

One of the first things, therefore, which an artist has to decide is how he proposes to treat a subject, keeping these three processes in view, by which his work will be reproduced, selecting the one from the first which will give him the results he requires, and working for that process in every stroke of the pen or brush. It is only in this way that satisfactory results can be obtained in the final print.

Besides these methods of reproduction which have been already described, the half-tone process is used for line work to give softness to the line, and in many cases the half-tone block when complete is handed over to the engraver to work up. This has been slightly done in the illustration facing this page, but is done to a greater extent in some of the American work. Fine results are also obtained by making a large woodcut and photographing down from it to make a process block. It is only fair to say in conclusion that half-tone process claims to give the widest range of any method for accurate reproduction of artists' work, and seems to do so in the hands of a good workman, though the ordinary commercial work is so poor.

Besides the production of process blocks by the methods already described, there are other methods of photographic reproduction, which do not lend themselves to printing off with type, but partake more of the nature of lithographic methods of reproduction, or the obtaining of impressions from a copper plate, each picture having to be printed off by itself in a special machine, after careful preparation.

Of these one of the most important is

Collotype

There are about forty varieties of collotype in use under different names, but the underlying method is the same.

WOODCUT

A negative is taken of the drawing as before, and a thin film of gelatine is spread on a sheet of plate glass, rendered sensitive to light, and then exposed under the negative. It is then placed in *cold* water. The cold water is unable to dissolve the gelatine, but is absorbed and causes the gelatine to swell. On the parts of the film which have been protected from light this swelling process can go on practically unhindered, but on the parts which have been exposed to light the swelling of the still soluble gelatine underneath is retarded by the insoluble film on the top, which results in the crinkling of the surface. To a certain extent this crinkling takes place all over the film, but principally over the insoluble portions, which consequently take up more ink, after the film has been dried. The result is that a collotype picture has a very slight irregular grain in it, quite different from the harder regular pattern of a half-tone process block, and half-tone is reproduced in it with great perfection.

It is a troublesome process to work, and the artist must be careful in the selection of his paper, and in avoiding shiny places, especially on the high lights; but it reproduces with far more delicacy and accuracy the half-tones of the original work than the *commercial* process block. Besides collotype there is

Photogravure

Photogravure is photographic etching in intaglio. The copper plate is prepared with a film sensitive to light, and after exposure, and the washing away of the soluble portions, the plate is bitten in, as a copper plate would be bitten in to produce an etching. It is used principally for reproducing pictures and etchings, and is the most difficult of these photographic processes, requiring great skill on the part of the workman. The grain is obtained by dusting the plate with powdered bitumen.

Besides these there are many other processes, such as photo-lithography and photo-zincography which consist of the application of photographic methods to lithographic processes. But none of them is of special interest to the artist, who is more concerned with process block work than anything else.

In conclusion, I may point out that success in black-and-white work necessitates the careful study of how each effect of the pen or brush will come out in the finished reproduction, and until that is learnt the artist cannot expect his drawings to be regarded with favour by the editors of magazines and others who are experts in the matter, no matter how beautiful they may be as drawings. Furthermore, the careful study of process work and the realisation of its limitations will result, not only in improved examples of this kind of work, but in the revival of the woodcut as the method which gives the feeling that can only be produced in work that has the hand and not the machine behind it.

CHAPTER XVI

TEMPERA PAINTING

THE conditions of painting have completely altered since the time of Van Eycke, and the effects aimed at by modern painters, especially those of the Impressionist school, do not admit of the same technical processes. Nevertheless, some painters still prefer tempera to oil-painting, and it is important for those studying the technical processes of the art to begin by examining the tempera processes even if they do not practise them. There are three things to be considered by the artist wishing to produce a permanent picture, namely the ground upon which it is painted, the pigments used, and the medium with which these pigments are prepared. Probably the fifteenth century saw all these brought to the greatest perfection compatible with permanence, and since then we have obtained new facilities in painting at the expense of durability.

Let us begin by considering the preparation of the painting surface for a tempera picture.

Tempera pictures are painted on wooden panels covered with a coat of gesso, and therefore the preparation of the panel first claims our attention. The wood usually used to-day is mahogany, and it seems to be a trustworthy material. The wood of the poplar was more commonly used in Italy. Small panels can be cut out of one piece of wood. This should be thoroughly-seasoned material, and the panels are best cut and planed up in the spring.

The panel should not be less than half-an-inch thick, and it is a good plan with panels more than nine or ten inches in size to cut a couple of undercut grooves in the back, across the grain, and let into these two slips of wood.

SECTION OF PANEL

These slips of wood must not be *glued* in, but must be left free to expand and contract, otherwise they will split the panel. If fitted in in the way described, they will preserve the panel from warping.

The panel can be planed up smooth, except on the side to receive the gesso.

This side should be gone over with a *toothing plane* so as to make a surface on which the gesso will firmly bite.

The panels having thus been prepared in the spring should be packed away in the carpenter's shop above the rafters where they may get plenty of air for twelve months. At the end of that time, those which have stood the test without warping or cracking may be prepared for painting with gesso.

A very bad custom has grown up of late years of laying the gesso directly on the smooth wood. Such a preparation is very likely to crack or scale off and cannot be regarded as satisfactory. The old Italian method of first pasting over the wood strips of linen is much better, as it holds the wood together and makes a good gripping surface for the gesso. The linen used should be old, and well washed, quite free from size, dressings, and chemicals. The glue used should be parchment glue. The method of toothing the surface described above is, however, quite satisfactory. At this stage of the process it is as well to take the panel to a good picture-frame maker. The gilders employed by these men have preserved a tradition of the utmost value, and, if proper workmen, may be trusted, after direction, to prepare a panel. They are accustomed among other things to prepare the parchment glue mentioned above.

The panel should first be covered with a wash of parchment glue well thinned with water.

Over this the first coat of gesso may be laid. The gesso may be prepared either from fine whiting or from plaster of Paris, which is fresh, or which has been mixed with a large quantity of water, and thoroughly stirred at intervals for some weeks. It is then obtained, after allowing it to settle and pouring off the water, in a very fine state of division, and can be dried and kept for use. This preparation seems to have been used in the fifteenth century, and is now used by Mr. Watts in preparing his canvases. It is, however, troublesome to prepare; whiting seems also to have been used with success from the earliest times. The prepared plaster of Paris or the whiting is mixed with weak parchment glue, and spread over the surface, so as to completely cover it, and roughly levelled with a spatula, without making it too smooth. It should then be allowed to dry for some days, and then have a thin coat of the gesso laid over the top and carefully smoothed and polished by means of fine glass paper. This, as explained above, is best done by a practical picture-frame gilder.

After the panel is dry, the artist should wash over it a thin coat of size, to make it non-absorbent, and the panel is then ready for tempera work. If, however, it is to be used for an oil-painting, the artist can prepare it first with a thin priming of such colour as may suit him best, mixed with oil, and laid over the gesso. A little white lead mixed with oil, and tinted slightly according to taste, makes a very good priming for this purpose.

In many cases the old panels underwent a further preparation before use, being entirely covered with gold leaf, laid on by the process known as *water-gilding*. There can be no doubt that this adds immensely to the durability of the work, and it is to be recommended when artists can afford the expense. It is, however, important to see that the best gold leaf is used, and that water-gilding is the process adopted, otherwise the results will not be so successful.

The gold surface is supposed to have a further advantage, as it is believed to add a peculiar quality to the more transparent pigments. This is said to be particularly true of flesh-painting, the greenish light thrown off by the gold being of great value under flesh tints.

Having now prepared our painting surface, we can proceed to paint on it, in tempera.

Tempera painting is done either with white of egg or yolk of egg.

If the white of egg is used, it must be thoroughly whipped up and allowed to stand for a few hours and the clear liquid poured off. The dry colour is then mixed with this and ground on a marble slab with a muller.

If the yolk of egg is used, the colour can be mixed with it and ground on the muller in the same way. It used to be the custom, in the fifteenth century, to mix with the egg medium a little fig-tree juice.

This juice contains caoutchouc, and doubtless adds to the toughness of the vehicle. Probably, however, the best medium is the yolk of the egg, and it may be trusted to give very durable results. Many artists at the present day mix vinegar or acetic acid with the yolk. This I cannot regard as a wise plan unless done with great care. There is no evidence of its being used at the best period of tempera painting, and the acid is likely to affect many pigments which are otherwise permanent. No more acid should therefore be added than just sufficient to neutralise the alkaline reaction of the egg as tested by litmus paper.

The difficulties of using this tempera medium are sufficiently obvious. The colours have to be fresh ground in it pretty frequently, as it does not keep, though by adding a little antiseptic it can be made to last for a few days, and it does not lend itself to easy manipulation with the brush, or to the effects which are now sought for in oil-painting.

Having completed a picture in tempera, it should be put on one side for four or five months, and then varnished. The best varnishes for this purpose are unfortunately no longer available. They were made principally of pine balsam, the silver pine for preference, in which a little of a harder resin, such as amber, had been dissolved, and a very little oil was added, the whole being heated together and thinned with turps or naphtha, and then put on warm. Four parts of balsam to one of amber and one of oil make a good varnish of this kind, and probably Canada balsam, which is now imported for mounting microscopic specimens, would do very well. To prepare the varnish, pour the Canada balsam, or balsam of the silver pine or Venice turpentine, into a hard round-bottomed glass flask, and heat over a lamp. Powder the amber, and add slowly to the balsam until it is all dissolved, then add the linseed oil and heat a little longer until a drop of the varnish taken out on the end of a glass rod, and put on a sheet of glass, remains quite clear on cooling. Remove the lamp, and cautiously add the turps, shaking the flask after each addition, till about as much turps has been added as the volume of varnish in the flask.

If it is too much trouble for the artist to prepare this varnish, he must content himself with a copal oil varnish, or a mastic varnish, which should be slightly warmed and laid over the picture. As the varnish flows over the picture all the colours change, and become more transparent, the final result being similar to an oil-painting. In this way the most durable pictures were produced in the past. If the picture has been painted on gold, and is then laid over with a varnish prepared as above described (which resists the passage of moisture and injurious gases), the result is that the colours are completely protected and locked up, and pigments we are accustomed to regard as fugitive are permanent under these conditions.

Sometimes in varnishing certain pigments absorb the varnish and dry dead. This is particularly true of terre verte. In such cases, a thin wash of size must be painted over the pigment before varnishing.

The palette should be limited, though probably all pigments safe in oil-painting may be safely used in tempera.

The picture should not be varnished till at least six months from the time of finishing it.

The colours ground first to a paste in water can be mixed on the palette with the yolk of egg, and the best brushes to use are sables.

This completes the main points that can be given here about tempera painting. Manipulation the artist must practise for himself.

CHAPTER XVII

FRESCO PAINTING

TRUE fresco painting or buon fresco is done upon a wet ground of lime and sand, only so much of the wall being covered with plaster each day as can be painted on.

Before being plastered, the wall, whether its surface be of stone, brick, or mortar, should be thoroughly wetted with rain or distilled water. The plaster is applied in two or more coats, the coarsest and thickest first.

The plaster consists of clean sharp white sand well washed and lime. There is danger in using the lime on the wall before it is thoroughly slacked, as, if not completely slacked, it cracks the plaster. Having slacked the lime and mixed it with the sand and sufficient water, it may be kept several days before being used. On the other hand, if the air is allowed to get at it, the carbonic acid in the air combines with it, reconverting it into carbonate of lime.

Now, the setting of the mortar is principally due to this slow change, and consequently if it takes place prematurely it will not set. Professor Church recommends running the thick cream of slacked lime into a tank and keeping it covered up before using for two months. This lime mixed with sand will do for the first layer of plaster. For the finer work it should be sifted through hair sieves and kept in stoneware jars with air-tight caps. The lime may safely contain a certain amount of carbonate, and this change takes place to a sufficient extent during the time it is in the tank. It is also of considerable importance that the lime be obtained from a pure carbonate of lime, such as a white marble or pure white chalk.

After the under surface of plaster was dry and before laying on the final surface on which the painting was done, it was customary during the best period of Italian art to draw out completely the design in charcoal, at the same time dividing the whole surface into squares, and shading the figures in chiaroscuro with the brush. Having completed this design, mix the specially-prepared lime with very fine sand and lay on a coat $\frac{1}{8}$ inch thick, over as much surface as you can paint in one day. Before laying on this coat, wet the surface thoroughly with rain or distilled water. After laying the plaster, wet with a large brush and rub over with the wooden tool used by plasterers for the purpose. The colours are mixed with water and laid on with soft brushes.

After care in the preparation of the plaster, the next thing to remember is that the palette which can be safely used in fresco is very limited indeed.

The earths, whiting, ivory black, charcoal black, cobalt blue, and cobalt green, should be the only colours used. Most modern frescoes go wrong because the palette is unduly extended. The colours are bound in position by the setting of the lime, that is, its conversion into lime carbonate by the carbonic acid of the air.

In *fresco secco* the plaster is allowed to become dry, and is then moistened as the painting proceeds with lime-water, and the pigments mixed with lime-water, and sometimes a little lime as well, instead of water alone.

This is an easier process than buon fresco, but is not nearly so durable as the other, the paints not being so firmly united to the plaster. The lime-water is very easily prepared by placing quicklime in water, and pouring off the clear water, after the lime has settled, into bottles carefully corked up to prevent ingress of carbonic acid gas.

Fresco cannot be regarded as a suitable method of painting in this country, as the climate is damp, and the air in or near our large towns impure. Consequently the pigments and ground are attacked by moisture and injurious sulphur compounds which cause the plaster to scale off, and the fresco is darkened by the smoke particles in the air. Once coated with these it is very difficult to clean the fresco again without injury.

The old form of fresco painting with lime has been largely replaced of late years by 'water glass' or silicate of soda processes (stereochromy).[1]

In these processes which have appeared from time to time with various modifications and under various names, the pigment is mixed with a solution of silicate of soda, which combines to form an insoluble compound with the lime on the wall and with some pigments. In this way the pigment is fixed to the wall surface, and is better protected from dirt and moisture than in the case of buon fresco. On the other hand, a special and limited palette is required for water-glass painting, as the solution used destroys certain pigments.

[1] The latest development of stereochromy is known as Keim's Process. Frescoes done by this process can be seen in a chapel at Blackheath, Chilworth, Surrey.

The artist wishing to use one of these processes must get the details from those supplying the materials, as they would occupy too much space here.

Its suitability for our damp, smoky climate is, I think, open to doubt, and personally, I prefer for this country *spirit fresco* processes as likely to prove more durable, and as being more easily cleaned.

Spirit fresco is really a modified form of oil-painting.

We owe this process to Monsieur Gambier Parry, though the medium used by him was unnecessarily complicated. In the first place, before the painting commences, it is essential not only that the plaster should be dry, but that the lime should have become completely saturated with carbonic acid. This can be tested by pressing on the wall, after first moistening it, a piece of turmeric paper, which can be obtained at any chemist's. If there is still pure lime in the plaster, the yellow paper will turn an orange brown. If the lime is completely saturated with carbonic acid, the paper will not change in colour, and the painting can be begun.

The composition of the different mediums has already been given. Professor Church recommends two parts of his medium mixed with three parts of turps to prepare the ground, and two or three applications of the mixture to the ground with a couple of days' interval to let it dry. The surface is then ready for priming. This should be done with a permanent white, ground in the medium. After priming, the surface must be left for three weeks before the painting is begun. The pigments should be ground in this medium, and turps used to thin the paints in laying them on. All pigments which are permanent in oil can be safely used. It is important to remember that the pigments dry dead, and therefore brilliancy is obtained by thin washes as in fresco work. Artists have sometimes attempted solid painting with this medium, and have naturally been disappointed with the results. Some colours, such as the madders, are apt to dry a little shiny, even though ground in this medium. In such cases, after they are dry, they should be washed over with a solution of ozokerite, or white wax in turps. A solution of wax in turps is sold as Parry's medium by artists' colourmen. It is also necessary to examine carefully whether the more absorbent colours such as the earths, and more especially burnt sienna, are firmly fixed to the wall, and if not, to touch them lightly over with the diluted medium.

Of course the use of white lead should be avoided throughout, especially in decorating buildings in towns, as if once darkened it will be impossible to bleach it again.

Spirit fresco gives great freedom to the artist, a wide palette, and durability, with fair protection of the pigments against moisture. It is therefore, in my opinion, most suited to fresco painting in this country.

Of the mediums described in the earlier part of the work, I have found Church's medium in which the ozokerite is replaced by beeswax the most satisfactory, as it fixes the colours better, and forms a permanent amalgam with the varnish instead of separating from it as the ozokerite does. It requires a larger proportion of turps.

CHAPTER XVIII

WATER-COLOUR PAINTING

WATER-COLOURS are prepared for use in three forms, the hard cake, the moist cake, and the tube colour. The basis in each case is gum water, though the method of preparation is varied according to what is required.

Besides gum water it is usual to add a little honey sugar, which tends to prevent the pigment cracking, and where the colour is to remain moist, a little glycerine.

The sugar used should be that obtained from old honey which has been kept some time, the best substance being the preparation of lævulose obtained by treating old honey with alcohol and evaporating off the alcohol. The sweet substance sold as 'Swiss honey' in pots contains large quantities of artificially-prepared lævulose, and will be found very suitable for adding to gum water for mixing up water-colour pigments.

Besides honey, a little glycerine may be added to keep the colour moist, and when all these are well mixed by gently warming and stirring, the colour can be ground in the mixture on a muller, and kept in a corked bottle ready for use. It will be of the consistency of Chinese white as sold in bottles.

The following proportions do very well for this purpose :—

Gum arabic, 8 parts.
Water, 30 parts.
Swiss honey, 5 parts.
Glycerine, 5 parts.

Dilute with water, and grind the pigment in this mixture.

The ordinary preparations of water-colours, as supplied by artists' colourmen, are quite satisfactory, the main question being the selection of a permanent palette. This is more difficult in the case of water-colours than in the case of oils, because the oil and varnish protect a pigment to a certain extent from the action of air, moisture, and deleterious gases, while in the case of water-colours the pigment is practically left without protection at all. Consequently, one or two pigments which are used in oil with comparative safety must not be used in water-colour. In the first place, white lead is replaced by 'Chinese white,' which is simply a zinc white prepared for water-colour work, and quite unchangeable.

It is as well, also, to exclude purple madder, and the use of brown madder is open to doubt, though, personally, I do not think it need be excluded.

With these precautions, the directions for selecting a palette for oil-painting will apply to water-colours as well.

The material on which the painting is done is also important. Only the best quality of paper prepared for water-colour painting should be used, as commoner papers are apt to contain injurious chemicals used for bleaching or for adulteration which stain the paper and destroy the pigments. The final picture should be mounted so as to allow for a free circulation of air between the picture and the glass, and should not be fastened down on any surface such as millboard, or resinous wood which might stain the paper. It should be kept as dry as possible, and should not be exposed to the direct action of sunlight. A little starch paste or pure gum arabic may be used for mounting, but made-up cements should be avoided.

CHAPTER XIX

OIL-PAINTING

Modern pictures are usually executed on canvas, though sometimes a panel is used. The preparation of panels has been already described. About canvas not much need be said. Canvas of good quality is easily obtained, and is prepared first by coating with size and then by priming with white lead, with which other pigments or other materials, such as whiting, may be mixed. In order to prevent cracking, a little olive oil is usually mixed with the linseed oil. This gives a nice flexible canvas. Some artists prefer a canvas merely sized, as they like the texture of the cloth to show through the painting, others prefer a glue ground.

There can be no doubt that many of the old canvas pictures were painted on gesso, and it has thus proved capable of standing the test of time; it has two defects. Unless laid on with great skill it is apt to crack off, and it is always liable to peel off if the back of the picture is exposed to damp air. Mr. Watts, among modern artists, always paints on a gesso ground, which he has prepared for him with great skill and care. No doubt the result will be permanent, if the pictures are carefully guarded from damp. To a certain extent an oil priming is affected by the same danger, the size being softened by damp, and so loosening the priming from the canvas. A combination of damp, followed by frost, is especially injurious. The possible injury in this way from frost seems to have been little noticed. And yet many pictures in galleries and elsewhere must often be exposed during the night to a sufficiently low temperature to freeze any moisture the canvas may have absorbed. In this way it is quite easy to crack off nearly all the priming from a piece of canvas in a few days, by leaving it exposed hanging up out of doors during changeable weather.

It is not usual to protect the back of canvases with a priming of paint, but there can be no doubt that this would be a useful precaution in all cases whether an oil priming or a gesso ground was used for the picture side of the canvas.

Having obtained a suitable piece of canvas, the artist proceeds to paint with oil colours already ground for him in oil by the artists' colourman. He may use the colour directly out of the tube, or he may mix it with some vehicle to thin it slightly before use.

Before considering the different mediums in use it will be as well to remind the artist of what he too often forgets, that the pigment already contains a large proportion of oil, and therefore whatever medium he may use is merely a mixture of that medium with the oil already present. This may seem an elementary fact to point out, but nevertheless much confusion of thought is sometimes caused by forgetting this.

The pigment then is delivered to the artist already ground in a certain proportion of oil.

This oil may be linseed oil, or nut oil, or poppy oil, and the amount present varies with different pigments. It is important to note at the outset that we have here a medium which only partially protects the pigment from gases or water vapour, and does not prevent certain pigments from acting injuriously on each other. We pay for having so delightful a medium to work in by at once introducing certain conditions which tend to diminish the life of the picture. Not only does the oil not exclude moisture or gases perfectly, but it makes it impossible to exclude them by means of varnishes, as being laid over the elastic oil surface they are bound to crack more or less and admit moisture to the interior. This is especially true of the varnishes which are moisture-tight, and which must contain *very little* or no oil at all.

Oil also yellows with age (though it can be bleached in the sun), and cracks in a most capricious manner. I have made many experiments with different media to try and determine causes of cracking, but have failed, because none of my experimental canvases will crack.

Doubtless hasty painting and hasty varnishing are mainly responsible for serious cracking, but many cases of cracking occur which it is difficult to explain or account for. Some conditions not thoroughly understood seem to facilitate cracking, causing it to take place in a most capricious manner. The trouble is that experiments seem to throw no light on the subject, because when we want to obtain cracking we cannot get it. Then it is impossible to obtain sufficiently accurate and detailed data from artists, to explain such cases as do occur in practice. Consequently, beyond the general directions given above, very little more can be said at present.

One most important fact for artists to remember is the tendency of whites to get more translucent with time.

This can easily be shown by covering black and white squares with white lead until they are completely painted out, and then keeping the surface so painted for a year or two. Gradually the check pattern appears again through the covering of white, showing the tendency of the white lead to grow more translucent with time. This is of great practical importance to artists, as it shows the danger of painting out dark parts of a picture with lighter colouring. In fact, in order to keep its brilliancy, an oil painting should not, if a section is cut through it at any point, pass from lighter to darker pigments downwards, but should pass always from darker to lighter pigments. For the same reason, a white ground probably does a good deal to preserve the permanent brilliancy of a picture.

It is also of importance to avoid an excess of oil or medium in painting. Mr. Watts, who is one of our most careful painters, always has his colours ground specially stiff, and avoids the use of additional oil. This leads naturally to the question of the use of mediums.

Raw or boiled oil, copal oil varnish, amber oil varnish, turpentine, and petroleum, may all be safely used, or the artist may mix them together to suit his taste. A little copal or amber varnish is useful, as it hardens the surface of the picture, oil alone being rather soft. Turpentine has the fault of not evaporating clean, but leaving some resin behind. This fault varies with different varieties of turps. Petroleum properly rectified is the cleanest of all mediums, as it evaporates completely and leaves no residue. Probably copal oil varnish thinned with petroleum is as safe and useful a medium as an artist can use.

For sketching it is sometimes useful to have the medium in the form of a jelly. This can be done by the addition of a little beeswax to oil or varnish. All patent mediums, all patent dryers, all dryers containing lead compounds, such as sugar of lead, and boiled oils and varnishes containing lead compounds, should be avoided.

Any oil, varnish, dryer, or medium, which on mixing with a little glycerine and a few drops of *sulphide* of *ammonium* turns dark brown, contains some lead compound and should be avoided.

Boiled oils and varnishes are now prepared with manganese instead of lead, and should always be used. A picture before varnishing should be gently washed, then put in a warm place to dry thoroughly. Mastic should be used and the varnish should be slightly warmed, and the picture finally rubbed with a warm dry cloth before the varnish is laid on. The picture should be kept before varnishing until it is at least six months old. The advantage of mastic over oil varnishes is that it is *easily removed* without injuring the picture, when cleaning is necessary.

In conclusion, I may refer artists wishing to study these subjects in more detail to Professor Church's work on *Paints and Painting*, which is full of most valuable information.

GLOSSARY OF PIGMENTS

(P for Permanent, F for Fugitive.)

Name.	In Oil.	In Water.	Buon Fresco.	Remarks.
Alizarine Lakes . .	P	P	F	These lakes are made from the dyeing principle of the madder root.
Antwerp Blue . .	P	P	F	A variety of Prussian blue.
Artificial Ultramarine	P	P	F	
Asphaltum . .	P	P	F	Bitumen.
Asphalt Brown . .	F	F	F	A variety of asphaltum.
Aureoline . . .	P	P	F	Cobalt yellow.
Aurora Yellow . .	P	P	F	A pale cadmium, specially prepared. See chapter on Artificial Yellows.
Azure Blue . .	P	P	P	A variety of cobalt blue.
Baryta White . .	P	P	P	Sometimes called permanent white.
Baryta Yellow .	P	P	F	Lemon yellow.
Berlin Blue . .	P	P	F	A variety of Prussian blue.
Bitumen . . .	P	P	F	A dangerous pigment. See chapter on Bitumens.
Blanc de Argent . .	P	F	F	A fine variety of white lead.
Blanc de Plomb . .	P	F	F	White lead. Turns brown in impure air. See chapter on Whites.
Blanc de Zinc . .	P	P	P	Zinc white.
Blanc Fixe . . .	P	P	P	Baryta white.
Blacklead . . .	P	P	P	
Bleu de Berlin . .	P	P	F	A variety of Prussian blue.
Bleu de Thenard .	P	P	P	A cobalt blue.

Name.	In Oil.	In Water.	Buon Fresco.	Remarks.
Blue Celeste	P	P	P	A variety of cobalt blue.
Blue Black	P	P	P	A charcoal black.
Bone Black	P	P	P	
Bone Brown	F	F	F	
Brown Madder	P	F	F	
Brown Red	P	P	P	A red ochre.
Brun Rouge	P	P	P	A red ochre.
Burnt Sienna	P	P	P	
Burnt Umber	P	P	P	
Burnt Ochre	P	P	P	
Cadmium Gelb	P	P	F	See chapter on Artificial Yellows.
Cadmium Yellow	P	P	F	See chapter on Artificial Yellows.
Caelin	P	P	P	A variety of cobalt blue.
Caelin Blau	P	P	P	A variety of cobalt blue.
Caledonian Brown	P	P	P	A brown earth.
Cambridge White	P	P	P	See chapter on Whites.
Cappagh Brown	P	P	P	A variety of umber.
Carmine	F	F	F	A cochineal lake.
Carmine de Garance	P	P	F	A madder lake.
Cassel Earth	F	F	F	See chapter on Bituminous Earths.
Caeruleum	P	P	P	A variety of cobalt blue.
Cerulean Blue	P	P	P	A variety of cobalt blue.
Cerulian	P	P	P	A variety of cobalt blue.
Ceruse	P	F	F	White lead.
Charcoal Black	P	P	P	
Cinnabar Green	F	F	F	Usually a mixture of chrome yellow and Prussian blue. Sometimes oxide of chromium, then permanent.
× Chinese Blue	P	P (F)	F	A variety of Prussian blue.
Chinese White	P	P	P	Zinc white.
Chrome Greens	F	F	F	
Chrome Red	F	F	F	
Chrome Yellow	F	F	F	
Cobalt Blue	P	P	P	
Colcothar	P	P	P	Red ochre.
Cologne Earth	F	F	F	See Bituminous Brown.
Crimson Lake	F	F	F	A cochineal lake.
Crocus	P	P	P	Red ochre.
× Cyanine Blue	P	P (F)	F	Cobalt blue and Prussian blue.

× See Prussian Blue.

Name.	In Oil.	In Water.	Buon Fresco.	Remarks.
Daffodil . . .	P	P	F	A permanent pale cadmium yellow. See chapter on Artificial Yellows.
Emerald Green	P	P	F	Must not be mixed with cadmium yellow.
Emerald Oxide of Chromium . . .	P	P	P	
Flake White . .	P	F	F	White lead. See chapter on Whites.
Foundation White	P	F	F	White lead.
Freeman's White .	P	P	P	
French Blue .	P	P	F	Ultramarine.
Gamboge . .	F	F	F	
Geranium Lake .	F	F	F	
Gelben Ocker . .	P	P	P	
Gmelin's Blue .	P	P	F	Ultramarine.
Golden Ochre .	P	P	P	
Graphite .	P	P	P	
Green Bice . . .	P	F	F	Malachite green.
Green Lake .	F	F	F	
Green Verditer . .	P	F	F	Malachite green.
Grune Erde .	P	P	P	Terre Verte.
Grune Chrome .	F	F	F	
Guimet's Blue . .	P	P	F	Ultramarine.
Hooker's Green .	F	F	F	
Indigo . .	F	F	F	
Indian Purple .	P	P	P	A purple ochre.
Indian Yellow . .	F	F	F	
Indian Lake .	F	F	F	
Indian Red .	P	P	P	A red ochre.
Italian Pink . .	F	F	F	
Ivory Black . .	P	P	P	
Jaune de Chrome	F	F	F	
Jaune Brilliant . .	P	P	F	A cadmium yellow. See chapter on Artificial Yellow.
Jaune de Cobalt . .	P	P	F	
King's Yellow	F	F	F	Orpiment.
Kobalt Gelbe . .	P	P	F	
Kobalt Blau .	P	P	P	
Krapp Lac . .	P	P	F	Madder lake.
Kremzer Weiss . .	P	F	F	White lead. See chapter on Whites.
Lamp Black . .	P	P	P	
Laque de Garance .	P	P	F	Madder lake.

Name.	In Oil.	In Water.	Buon Fresco.	Remarks.
Laque Robert	F	F	F	
Lemon Yellow	P	P	F	
Light Red	P	P	P	Red ochre.
Madder Lake	P	P	F	
Magenta	F	F	F	
Malachite Green	P	F	F	
Mars Brown	P	P	P	An artificial brown ochre.
Mars Orange	P	P	P	An artificial brown ochre.
Mars Red	P	P	P	An artificial red ochre.
Mars Violet	P	P	P	An artificial purple ochre.
Mars Yellow	P	P	P	An artificial yellow ochre.
Mauve	F	F	F	
Miller's Green	P	P	P	Oxide of chromium.
Mineral Green	P	F	F	Malachite green.
Mineral Yellow				
Mummy	P	F	F	
Mutrie Yellow	P	P	F	A cadmium yellow. See chapter on Artificial Yellow.
Naples Yellow	P	F	F	
New Blue	P	P	F	Ultramarine.
New Flake White	P	P	P	See chapter on Whites.
Ocre Jaune	P	P	P	
Olive Lake	F	F	F	
Orient Yellow	P	P	F	A cadmium yellow. See chapter on Artificial Yellow.
Orpiment	F	F	F	
Oxford Ochre	P	P	P	
Oxide of Chromium	P	P	P	
Palladium Red	F	F	F	
Palladium Scarlet	F	F	F	
Pariser Blau	P	F	F	A Prussian blue.
Patent Yellow	F	F	F	
Permanent Blau	P	P	F	Ultramarine.
Permanent White	P	P	P	Baryta white.
Permanent Weiss	P	P	P	
Persian Red	F	F	F	
Pink Madder	P	P	F	
Platina Yellow	F	F	F	
Plumbago	P	P	P	
Prussian Blue	P	F	F	
Prussian Green	F	F	F	
Pure Scarlet	F	F	F	
Purple Lake	F	F	F	

Name.	In Oil.	In Water.	Buon Fresco.	Remarks.
Raw Sienna	P	P	P	
Raw Umber	P	P	P	
Red Lead	F	F	F	
Red Ochre	P	P	P	
Rembrandt's Madder	P	P	F	
Rinmann's Green	P	P	P	A cobalt green.
Roman Ochre	P	P	P	
Rouge	P	P	P	A red ochre.
Rouge Anglais	P	P	P	A red ochre.
Rose Madder	P	P	F	
Rubens' Madder	P	P	F	
Ruby Madder	P	P	F	
Sap Green	F	F	F	
Saxon Blue	P	P	F	A Prussian blue.
Scarlet Chrome	F	F	F	
Scarlet Lake	F	F	F	
Scheele's Green	P	P	F	A variety of emerald green.
Schweinfurt Green	P	P	F	A variety of emerald green.
Sepia	P	P	F	
Silver White	P	F	F	A white lead. See chapter on Whites.
Smalt	F	F	F	
Terra de Verone	P	P	P	Terre verte.
Terre Verde	P	P	P	
Terre Verte	P	P	P	
Terra Rosa	P	P	P	A red ochre.
Turnbull's Blue	P	F	F	A variety of Prussian blue.
Turner's Yellow	F	F	F	
Ultramarine	P	P	F	
Ultramarine Ash	P	P	F	
Vandyke Brown	F	F	F	See Bituminous Earths.
Venetian Red	P	P	P	
Verdigris	F	F	F	
Vermilion	P	P	F	
Verona Brown	P	P	P	A variety of umber.
Veronese	P	P	F	Emerald green. Do not mix with cadmium yellows.
Vert de Cobalt	P	P	P	
Vert de Chrome	P	P	P	An oxide of chromium.
Vert de Guignet	P	P	P	An oxide of chromium.
Vert de Montagne	P	F	F	A malachite green.
Vert de Zinc	P	P	P	A cobalt green.
Vert Emeraude	P	P	P	Viridian.
Vert Paul	P	P	F	An emerald green.
Violet Carmine	F	F	F	

Name.	In Oil.	In Water.	Buon Fresco.	Remarks.
Virgin Gold Ochre .	P	P	P	
Viridian .	P	P	P	An oxide of chromium.
White Lead .	P	F	F	See chapter on Whites.
Yellow Carmine . .	F	F	F	
Yellow Madder . .	F	F	F	Not a madder lake.
Yellow Ochre . .	P	P	P	
Yellow Ultramarine .	P	P	F	A lemon yellow.

INDEX

LIST OF APPARATUS AND CHEMICALS REQUIRED

1 oz. Chlorate of Potash	£0	0	3
1 oz. Iron Filings	0	0	2
1 oz. Salamoniac	0	0	2
1 oz. Black Oxide of Manganese	0	0	2
1 oz. Gum Arabic	0	0	3
1 oz. Asphaltum	0	0	2
1 oz. Cobalt Nitrate	0	0	9
1 oz. Ammonia	0	0	4
1 oz. Strong Sulphuric Acid	0	0	4
1 oz. Nitric Acid	0	0	4
1 oz. Hydrochloric Acid	0	0	4
1 oz. Ammonium Sulphide	0	0	4
1 oz. Sulphate of Iron	0	0	4
1 oz. Lead Acetate	0	0	2
1 oz. Sodium Sulphate	0	0	3
1 oz. Sodium Hyposulphite	0	0	2
1 oz. Acetic Acid	0	0	4
1 oz. Barium Chloride	0	0	2
1 oz. Potassium Chromate	0	0	3
1 oz. ,, Bichromate	0	0	3
1 oz. Cadmium Sulphate	0	0	7
1 oz. Alum	0	0	2
1 oz. Sulphate of Copper	0	0	2
1 oz. Potassium Ferrocyanide	0	0	4
1 oz. Boracic Acid	0	0	2
1 oz. Gypsum	0	0	2
1 oz. Soda	0	0	1
1 oz. Barytes	0	0	6
1 oz. Alizarine	0	1	0
1 oz. Alumina	0	0	4
1 oz. Spirits of Wine	0	0	2
Pieces of Marble	0	0	3
Thin Iron Wire	0	0	3

Stout Copper Wire	£0	0	3
Bitumen	0	0	3
Mortar and Pestle	0	1	5
1 doz. Test-tubes	0	0	6
Small Test-tube Stand	0	1	0
Nest of 6 Beakers	0	2	3
Crucible Tongs	0	1	0
Platinum Foil 2″ × 1″	0	1	3
2 Spirit Lamps	0	1	8
Mouth Blowpipe	0	0	6
Stoneware Tray	0	0	10
Gas Jar	0	0	8
Packet of Filter Papers	0	0	4
2 Glass Funnels	0	0	5
Funnel Stand	0	1	6
Bottle with Tube, Cork, and Thistle Funnel	0	0	8
2 Round-bottom Hard Glass Flasks	0	0	8
Stoppered Bottle, 4 oz.	0	0	4
2 Small Spatulas	0	1	0
2 Iron Tripods	0	1	8
Box for holding 1 doz. ¼ Plates	0	0	10
Muller and Slab	0	6	0
3 Porcelain Plates	0	0	6
Frame with Sheet of Glass in it	0	3	6
1 doz. Glass Plates twice the size of ¼ Plates	0	2	0
Frame for Exposing Glass Plates	0	5	0
Glass Plate, 5″ sq.	0	0	3
Small Sheet Iron Dish	0	0	6
Small Iron Ladle	0	0	10
2 Wide-mouthed Bottles, 8 oz.	0	0	6
1 oz. Cochineal	0	0	5
1 oz. Linseed	0	0	3
1 oz. Crimson Lake	0	3	0
1 oz. Madder ,,	0	3	0
1 oz. Alizarine ,,	0	3	0
1 oz. ,, ,,	0	3	0
1 oz. Carmine	0	4	6
1 oz. Oxide of Chromium	0	3	0
1 oz. Cobalt Green	0	3	0
1 oz. Cobalt Blue	0	5	0
1 oz. Chinese Vermilion	0	2	6
1 oz. Cadmium Orange	0	6	0
1 oz. Daffodil No. 1	0	6	0
1 oz. ,, No. 2	0	6	0
1 oz. Cobalt Yellow	0	6	0
1 oz. Cyprus Umber	0	1	0
1 oz. Raw Sienna	0	0	6
1 oz. Golden Ochre	0	0	6
1 oz. Oxford Ochre	0	0	6
1 oz. Virgin Gold Ochre	0	0	6
1 oz. Chrome Yellow	0	0	6

	£	s.	d.
1 oz. Red Ochre	£0	0	6
1 oz. Purple Ochre	0	0	6
1 oz. Burnt Sienna	0	0	6
1 oz. Terre Verte	0	0	6
1 oz. Raw Umber	0	0	6
1 oz. Burnt Umber	0	0	6
1 oz. Cappagh Brown	0	0	6
1 oz. Vandyke Brown	0	0	6
1 oz. White Lead	0	0	6
1 oz. Best Flake White	0	0	6
1 oz. Freeman's White	0	0	6
1 oz. Zinc White	0	0	6
1 oz. ,, ,, (Condensed)	0	0	6
1 oz. Naples Yellow	0	0	6
1 oz. English Vermilion	0	0	6
1 oz. Prussian Blue	0	0	6
1 oz. Emerald Green	0	0	6
1 oz. Chrome Green	0	0	6
1 oz. Ivory Black	0	0	6
1 oz. Verdigris	0	1	0
1 oz. Lamp Black	0	1	0
1 oz. Vine Black	0	1	0
1 oz. Ultramarine	0	1	0
1 oz. Cerulean Blue	0	1	6
1 oz. Indigo	0	2	0
Tube of Yellow Ochre	0	0	4
1 oz. Poppy Oil	0	0	3
1 oz. Linseed Oil	0	0	3
1 oz. Turps	0	0	3
1 oz. Petroleum	0	0	3
1 oz. Whiting	0	0	1
Varnished and Dovetailed Box with Lock	0	12	0
	£6	16	4

THE END

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