



1969

Dictionary of Artists' Oil Pigments: Their Chemical and Physical Properties

R. Bruce Handlong '69
Illinois Wesleyan University

Follow this and additional works at: https://digitalcommons.iwu.edu/art_honproj



Part of the [Arts and Humanities Commons](#)

Recommended Citation

Handlong '69, R. Bruce, "Dictionary of Artists' Oil Pigments: Their Chemical and Physical Properties" (1969). *Honors Projects*. 2.

https://digitalcommons.iwu.edu/art_honproj/2

This Article is protected by copyright and/or related rights. It has been brought to you by Digital Commons @ IWU with permission from the rights-holder(s). You are free to use this material in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you need to obtain permission from the rights-holder(s) directly, unless additional rights are indicated by a Creative Commons license in the record and/ or on the work itself. This material has been accepted for inclusion by faculty at Illinois Wesleyan University. For more information, please contact digitalcommons@iwu.edu.

©Copyright is owned by the author of this document.

DICTIONARY OF ARTISTS' OIL PIGMENTS:
| THEIR CHEMICAL AND PHYSICAL
PROPERTIES

by
R. Bruce Handlong

//

ARCHIVES

751

H236d

Submitted for Honors Work
In the Department of Art
Illinois Wesleyan University
Bloomington, Illinois
1969

Illinois Wesleyan Univ. Libraries
Bloomington, Ill. 61701

Accepted by the Department of Art of Illinois
Wesleyan University in fulfillment of the requirement
for departmental honors.

May 7, 1969
Date

Russell Kilgus
Project Adviser

PREFACE

This work is primarily intended as a reference for the artist who seeks to know more about the chemical and physical properties of oil pigments that he has at his disposal. By better understanding these properties, the artist can insure the durability and permanency of his creations and, also, give him a firm foundation on which he may begin to develop an individual style.

In preparation of this dictionary, I was concerned only with the standardization of color names of oil pigments. I was not concerned with color theories of Munsell, Ostwald, or Young-Helmhotz. All the color terms that were ambiguous or irrelevant were omitted. The substance of this work is compiled in encyclopedic form, and to facilitate reference, an index is appended.

Acknowledgment is due to two of my instructors: Dr. Wendell W. Hess, chemistry, and Mr. Benjamin W. Vrana, German. With their personal counseling I was able to write this paper.

April 27, 1969

R. B. Handlong

TABLE OF CONTENTS

PREFACE	iii
INTRODUCTION	1
SOURCES OF PIGMENTS	1
HOW COLORS WERE MADE IN THE PAST	5
METHODS USED TO TEST PIGMENTS	8
LIST OF COLORS	14
PIGMENTS	17
<p style="text-align: center;">Their Chemical and Physical Properties, Com- position, Synonyms, Characteristic Distin- guishing Tests, History and Source.</p>	
INDEX	84
BIBLIOGRAPHY	86

DICTIONARY OF ARTISTS' OIL PIGMENTS:
THEIR CHEMICAL AND PHYSICAL
PROPERTIES

INTRODUCTION

It has frequently been observed that while Hubert and Jan Van Eyck, Dürer, da Vinci, Seurat, and other master painters knew the capabilities of the pigments they used, the artists of today do not. They are hesitant to concern themselves too closely with this study.

Out of the need for a better understanding of artists' oil pigments--their chemical and physical properties--has grown this present work. It is based upon intensive study of all past authors, making free use of their best points and acknowledging them for their labors and attempting to avoid those points which have found to be impractical. The ideal has been to present, in essentially usable form, a dictionary of artists' oil pigments, to be used as a reference for the artist.

SOURCES OF PIGMENTS

Pigments are the coloring matter needed for paints. They must be substances which can be powderized so that

they can be mixed with a liquefied binder. The four sources of pigments are: natural, artificial, organic, and inorganic. It is simpler to classify them as earth colors, mineral (or metallic) colors, organic colors, and chemical colors.

The earth colors are not really made of earth but various oxides of iron. The name was applied to them when "earth" was believed to be one of the four elements constituting the earth. The other three elements were air, fire, and water.

The iron ore used for preparing the colors can be obtained from practically anywhere on the surface of the earth. The prepared colors range in hue from yellow through diverse shades of buff, brown, and green, to red and violet. The colors may be used as they are, but many of them (like raw siena and raw umber) can be calcined to produce darker hues (like burnt siena and burnt umber). Earth colors are lowest in price in all brands and are permanent.¹

The mineral colors are obtained from metallic elements. Various grades of white are made from aluminum, lead, titanium, and zinc. The various grades are Trans-

¹Ralph Fabri, COLOR: A COMPLETE GUIDE FOR ARTISTS, (New York: Watson-Guptill Publications, 1967), p. 74.

parent White (aluminum hydroxide), White Lead (lead carbonate), Titanium White (titanium dioxide), and Zinc White (zinc oxide). Other elements that are used to produce pigments are antimony, cadmium, chromium, copper, manganese, mercury, and strontium. The pigments produced are, respectively: Naples Yellow (lead antimoniate), Cadmium Yellow (cadmium sulphide), Chromium Oxide, Transparent (hydrated chromic oxide), Emerald Green (copper arsenate), Manganese Violet (manganese ammonium phosphate), Vermilion (mercuric sulphide), and Strontium Yellow (strontium chromate). Most of the colors made from metallic elements are permanent. They are costlier than earth colors for they have to be mined and carefully processed.

The organic colors are made from animal and vegetable matter. Many of these colors were used in the past. One of these colors is Indian Yellow, an impure magnesium and calcium salt of euxanthic acid-- $C_{19}H_{16}MgO_{11}.5H_2O$. It was developed in 1735. It is prepared from the urine of cows that are principally fed on mango leaves. The food stimulates the secretion of bile which the excess of strongly colors the urine. It is made at Monghyr in Bengal by the tribe of people known as Gwalas.

The permanency of colors produced from organic matter is questionable. Organic colors are being replaced by mineral and chemical colors. The reason for the replace-

ment is two-fold. First, the quantity of pigments prepared from organic matter is not sufficient enough to meet the demands of the artist. The production of Indian Yellow is restricted to the amount of urine produced. Normally, only two ounces of Indian Yellow is obtained daily from one cow producing $3/4$ of a gallon of urine.² Secondly, the quality of pigments produced from mineral and chemical substances are more uniform in their permanency than are the pigments produced from organic matter.

The chemical colors are produced in the laboratory. For a hundred years chemical pigments were unreliable. They looked fine when applied but later faded or changed rapidly often ruining the whole work. One chemical would react to another and destroy the effect planned by the artist. Before World War I, certain colors bore warning labels: "Do not mix with such-and-such color."

Chemically produced pigments are now more uniform in color and quality than natural ones. Mars colors are a notable case. They are artificial ochres derived from the hydrate and oxide of iron. All Mars colors--black, red, violet, and yellow--are fully reliable. Reliability, however, does not necessarily imply brilliance. If truly

²F. W. Weber, ARTISTS' PIGMENTS: THEIR CHEMICAL AND PHYSICAL PROPERTIES, (New York: D. Van Nostrand Company, 1923), p. 67.

bright colors in reds and yellows are desired, it is advisable to use cadmium colors.³

HOW COLORS WERE MADE IN THE PAST

Until early in the nineteenth century, artists prepared their own colors and other art materials or had apprentices to do their work. The number of colors was limited because only natural pigments were employed. Artists of the Renaissance and Baroque periods, from the fifteenth to the eighteenth century, worked with a palette of six to twelve hues. Leonardo da Vinci (1452-1519) asserted that the artist needed only six colors: white, the color of light; yellow, the color of earth; green, the color of water; blue, the color of the air; red, the color of fire; and black, the color of total darkness.⁴

used a real blue or green; they preferred the golden, warm tones which were in keeping with the luxurious life of the fabled city on the lagoons.

Each school had its own special likes and dislikes in color. Very often this preference was due to the fact that certain colors were unavailable. From a specific color used in a painting, we can often tell where a cer-

⁴Ibid., p. 80.

tain painting must have been painted. The period can, also, be recognized by the fact that a certain color--not introduced until a certain date--is employed in the painting. All the materials were tested by the master. The paintings, as a result, that have survived are still in fine condition.

By the middle of the nineteenth century, most artists were producing small easel paintings for they hoped to sell them to "bourgeois" clients. The days of large paintings and mural commissions seemed to be over. There was neither room nor money nor a demand for such works on the part of the rapidly growing middle class, the new patrons of the arts. Painters now went outdoors to paint instead of painting in their studios. The painters no longer had scores of assistants helping them. They had no time, no space, no patience, and no inclination to bother with preparing a few tubes of paint. The labor of making paints was separated from the art of painting pictures.

Craftsmen were, now, employed to produce paints. For a while, there was a deterioration of quality. Colors were not tested in regard to purity, permanence, and mixability. Many chemically obtained colors turned dark or light within a short time. Some colors dried faster than other, and when a fast-drying paint was applied over slow-drying ones, cracking was inevitable. These reactions can

be observed by viewing any one of Albert P. Ryder's paintings. The paintings of his that have been collected were painted primarily in the late 1880's. Each painting has become dark and profusely cracked.

As the demand for colors grew, manufacturers began to compete for the artists' trade. They first increased the diversification of hues to attract the artists' eyes. And, secondly, they introduced inventions that would ease the artists' labors. The roll-up metal tube was invented to replace the clumsy pouches, made of animal bladders, in which paint was marketed and kept.⁵

With these introductions, there were disasters. The biggest was the introduction of asphalt black. (This should not be confused with asphaltum which was introduced as an oil in 1598). Asphalt was a beautiful, warm black. Unfortunately, asphalt had a very low specific gravity; it could float on water. After a while, it would rise to the surface of a painting. The asphalt would discolor and turn everything dark. Many paintings, executed before the turn of the twentieth century, have turned almost black now. A few white spots remain in the darkness of the painting because there was no asphalt in them.

After a while, the manufacturers and artists

⁵Ibid., p. 76.

realized that this haphazard way of producing paints could not continue. Today, major manufacturers guarantee the purity, dependability, and mixability of their colors. Many of them list the ingredients on the label of each tube. Others list them in their catalogs which are available to all artists. It is now entirely up to the artist to work with the right colors and materials.⁶

METHODS USED TO TEST PIGMENTS

The artist interested in determining qualitatively the purity of any color should keep the necessary reagents for this purpose and refer to the various tests for each pigment in question, under its respective listing. A small wooden box should be kept in the studio, in which several bottles of necessary reagents may be safely kept, ready for use at any time. A complete assortment to make the usual tests, should comprise a bottle each of

Water

Alcohol

Sodium Sulphide in Water Solution

Hydrochloric Acid

Sulphuric Acid

⁶Ibid., p. 77.

Nitric Acid

Ammonium Hydroxide

Sodium Hydroxide in Water Solution

Lime Water

Potassium Ferrocyanide in Water Solution

Ferric Chloride in Water Solution⁷

Barium Chloride in Water Solution

Silver Nitrate in Water Solution

Red and blue litmus paper

About six test tubes with small glass funnel

Filter Papers

The technique employed in testing a color is as follows: Although some tests can be made with oil colors without the oil or gums interfering with the reactions, it is preferred that the pigment be in a dry powder form. The dry powder pigment responds to reactions more accurately and definitely than the oil color. It is necessary that the oils, gums, and wax be removed before testing the pigment.

The oil-color pigments should be washed free of the oil by squeezing a small amount, about a thimbleful, of the color in a test tube, adding turpentine in excess and shake until the color and turpentine are thoroughly mixed, allow the pigment time to settle, then filter. If necessary repeat several times, adding fresh turpen-

⁷Weber, ARTISTS' PIGMENTS, p. 11.

tine, until all the oil is removed, leaving only the pigment upon the filter paper. Any turpentine remaining with the pigment should be removed by using alcohol in the same manner as the turpentine was used. It should now be observed whether the turpentine, or the alcohol, filtered off colorless; a colored solution would indicate the presence of soluble dye-stuffs or other soluble substances. Some extremely fine pigments filter through with the first filtrate and the artist should not mistake this for a colored solution, indicating dye-stuffs or other soluble coloring matter, as the solution usually filters clear after carefully re-filtering. When dyes are present the filtered solution will remain colored even after re-filtering several times.⁸

First, the chemical composition of the pigment must be determined in order to further test its purity and properties as a durable color. If the name of the pigment in question be known, reference should be made to the various tests employed in its detection, listed under its respective name in the second half of this paper. If on the other hand, the identity of the color is not known, reference should be made to the listing of several colors of similar appearance with their distinguishing reactions.

To illustrate this more clearly, let us, for ex-

⁸Ibid., p. 12.

ample, assume that we have four blue pigments, which optically resemble each other very closely, and it is desired to know which of the four are desirable as durable pigments and of what they are composed.

Primarily, we are concerned with the composition of the four pigments. It is necessary to determine these factors first. After this is known, it is a simple matter to refer to the chemical and physical properties of each respective color as listed in this paper.

Each sample is first washed in turpentine and then alcohol. If any of the four yield a colored filtrate, this would indicate the addition of a dye-stuff or other soluble coloring matter. The turpentine filtrate may also be tested for soluble salts. These salts are present should the pigment be insufficiently washed when made, or they may have been added as adulterants. Detection: allow the filtrate to evaporate to dryness on a shallow crystal when more than a mere trace of residue would indicate the presence of soluble impurities.

Next, reference should be made to the pigments that are commonly employed. These pigments are Cobalt Blue, Ultramarine⁹ and Prussian Blue. Upon comparing the various reactions common to each pigment, we see

⁹Ibid., p. 13.

that upon the addition of a drop of dilute hydrochloric acid to each of the samples, only Ultramarine will be reacted upon by the acid for Cobalt Blue and Prussian Blue are insoluble in dilute acids. The Ultramarine may be further affirmed by referring to the characteristic chemical properties of this pigment. The Cobalt and Prussian Blue are physically so different that usually they are readily recognized, however knowing that Prussian Blue is reacted upon by alkaline solutions, the Cobalt Blue will remain unaffected upon the addition of this reagent. Each may be further definitely recognized by distinguishing reactions listed under their chemical and physical properties.

The addition of any insoluble or inert extender, such as whiting, clay, barytes, alumina, silica, etc., may be detected by referring to the characteristic test for these substances. The tinting strength and color value of the pigment is greatly reduced when these are present in any appreciable amount. The color may be compared in tinting strength and color with a known pure standard color. A simple method of doing this is to weigh off exactly the same amounts of each color and mix with an equal amount of pure zinc white, using the same quantity of oil for each. Compare the tint obtained from the sample pigment with the tint of the known standard.¹⁰

¹⁰Ibid., p. 14.

But if the artist does not want to employ this type of testing, he may simply use the heating test. It is practical and dependable. The sample of the pigment is taken up on a spatula and gently heated over an alcohol flame. The reactions that occur are characteristic of the specific pigment. White lead turns permanently yellow; zinc white turns temporarily yellow, ocher red, and green earth a yellowish brown; vermilion disappears completely; coal-tar and other organic pigments leave a colorless residue.¹¹

The artist may, also, use the flame test to determine another characteristic of the sample pigment. The simplest way to run a flame test is to shape a piece of fine platinum wire into a loop, dip the loop in HCl solution and heat to remove volatile impurities, and then use the loop to heat the sample in a burner flame.¹² The results obtained can be compared with the chemical and physical properties of each respective pigment as listed in this paper.

In order to determine whether or not a pigment is lightproof, it is mixed with ~~gun~~-water and a very thin

¹¹Max Doerner, THE MATERIALS OF THE ARTIST AND THEIR USE IN PAINTING WITH NOTES ON THE TECHNIQUE OF THE OLD MASTERS, trans. by Eugen Neuhas, Ph.D.h.c., (New York: Harcourt, Brace and Company, 1934), p. 48.

¹²Michell J. Sienko and Robert A. Plane, CHEMISTRY, (New York: McGraw-Hill Book Company, 1966), 3rd. ed., p. 397.

layer put on white paper which will not turn yellow; half of the paper is then covered up, perhaps by being placed in a book. After the sun has shone on the exposed half for some time, this should show no change. Most organic colors are not lightproof; many bleach in a few hours, others turn brown. Vermilion, when exposed to light, develops black spots, and madder lakes fade when exposed to light.

A pigment is oilproof if, when mixed with oil, it does not dissolve or change its hue. Pigments which are not oilproof "strike through," they "bleed," that is to say, they penetrate through superimposed coats and come to the surface.

Newly developed pigments should be received with caution, no matter how tempting their color appears. Often enough defects become apparent which were not at first evident, such as its sensitiveness to light and/or lack of stability in oil.¹³

LIST OF COLORS

To Adolf Wilhelm Keim and the Deutsche Gesellschaft zur Forderung rationeller Malverfahren founded by him at Munich, we are indebted for our basic ideas in the field of color. A normal color list was set up

¹³Doerner, THE MATERIALS OF THE ARTIST, p. 49.

in 1886.¹⁴ The original list comprised the following colors:

1. Cremnitz white.
2. Zinc white.
3. Cadmium, light, dark, orange.
4. Indian yellow.
5. Naples yellow, light, dark.
6. Yellow and brown, natural and burnt ochers, sienna.
7. Red ocher.
8. Iron oxide colors.
9. Graphite.
10. Madder lake.
11. Vermilion.
12. Umber.
13. Cobalt blue.
14. Ultramarine blue.
15. Paris blue.
16. Oxide of chromium, opaque and transparent.
17. Green earth.
18. Ivory black.
19. Vine black.

Today we should add to this list cadmium red and titanium white. The above set of colors enables you to

¹⁴Ibid., p. 93.

mix any possible color and shade except special chemical colors.¹⁵

STANDARDIZATION OF COLOR NAMES

On examining back through the years the subject of color names as identifying certain color sensations, it will be found that there exists no authority to which one may turn for an unqualified answer. The cause of this disagreement is the lack of anything in the color name to indicate unerringly a specific color sensation.

One of the wildest color names in the human language is "Grass Green." It was recorded as early as 700 in Old English. Grass is translucent and shows color by transmission and reflection of light. Its color is altered by surrounding objects and especially by the blue light of the sky. But beyond this, there is even a change of color caused by the wind, which bends the blades about, so that they are now transmitting, now reflecting light from various directions.

To determine what color is meant by the term "Grass Green," a normal condition of aspect has to be created. This grass plot would have to be in the temperate zone at a place not lower than thirty-six degrees Latitude, of average good mixture of varieties, observed

¹⁵Ibid., p. 94.

at a distance of from one to ten yards, during mid-day, in midsummer, on a day with no wind, away from overshadowing trees, and with a low background, that is, not shut in by close, high trees in the direction of sight (which could darken the color); the character of light to be diffuse, wither an overcast but not heavily clouded day, or in such shadow as does not in any way alter the normal conditions outlined above.¹⁶

Conditions, such as these, can not always be set up to exemplify what is meant by an ambiguous color term. To arrive at the standard color term for any pigment, it is necessary to take the average from general practise.

The term, "Oxide of Chromium, Transparent," would be a better substitute to describe the color of grass than "Grass Green." Oxide of Chromium, Transparent, is hydrated chromic oxide-- $\text{Cr}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$. It is generically called "Emeraude Green" and/or "Viridian." It is a specific color sensation.¹⁷

In other words, the only possible authority by which an acceptable standard can be established is by a consensus of opinion drawn from sufficiently wide sources.

¹⁶Aloys John Maerz, and M. Rea Paul, A DICTIONARY OF COLOR, (New York: McGraw-Hill Book Company, 1930), p. 161.

¹⁷Weber, ARTISTS' PIGMENTS, p. 97.

PIGMENTS

The names appearing here are those of permanent oil pigments. Each pigment is listed by its most commonly recognized trade or scientific name. The synonyms and chemical composition of the pigment are included along with a description of its etymology, history, preparation, and chemical and physical properties. The pigments are arranged in alphabetical order, irrespective of their various chemical and physical properties, the intention being to facilitate reference.

ALIZARIN LAKES

Aliz. Blue; Aliz. Carmine; Aliz. Crimson;
Aliz. Green; Aliz. Orange; Aliz. Scarlet;
Aliz. Yellow; Rose Madder Aliz.; Aliz.
Madder Lake; Aliz. Burnt Carmine; Indian
Lake Aliz.; Permanent Violet; Permanent
Crimson; Aliz. Sap Green; Aliz. Olive
Green; Aliz. Olive Lake; Aliz. Crap Lakes;
Scarlet Crap Lake; Violet Carp Lake; Laque
d'alizarine carmosie; Lacca d'alizarina
cremisina; Laca de garanza cramois;
Alizarin Farben

ALIZARIN-- $C_{14}H_6O_2(OH)_2$ --is the active coloring principle. The coloring principle is, with few exceptions, precipitated on a neutral base of Alumina Hydrate, which as a pigment yields, when ground in oils, very brilliant, transparent colors.

Before the development of the Alizarin colors from anthracene, a coal-tar derivative, the madder root was the source of this color extraction for many centuries.¹⁸ From the madder root there are two coloring extracts, the permanent ALIZARIN-- $C_{14}H_8O_4$ --and the quickly fading PURPURIN-- $C_{14}H_8O_5$.¹⁹ The Alizarin extract yields the more permanent lakes of brilliant crimson, rose, purple, violet and maroon hues, varying according to the concentration, purity and base upon which it is precipitated. Purpurin yields pigments more orange or red in hue. The synthetic or artificial Alizarins are rapidly displacing the madder extracts, being of richer hue if properly manufactured and more permanent.

Sodium Hydroxide entirely dissolves Alizarin and Madder Lakes (on alumina base) to a blue-violet solution (Purpurin yields a cherry-red solution), which, upon the addition of dilute Sulphuric Acid in excess, loses its color with formation of a flocculent, colored precipitate²⁰

¹⁸Weber, ARTISTS' PIGMENTS, p. 16.

¹⁹Doerner, MATERIALS OF THE ARTIST, p. 76.

²⁰Weber, ARTISTS' PIGMENTS, p. 16.

of the dye-stuff (orange-yellow in color if Alizarin and bright red if Purpurin), leaving the supernatant liquid practically colorless. Carmine or Carmine Lake are detected by their leaving the acidified solution more or less intensively red in color.

Alizarin and Madder Lake are insoluble in water and alcohol; a colored solution would indicate the addition of dyes.

Alizarin Madders and Madder Lakes are perfectly durable and safe in admixture with the calcined or burnt earth pigments, such as Bt. Sienna, Bt. Umber, Bt. Ochres, Burnt Iron Oxide Colors, and Burnt Terre Verte, but not always with the natural earths, such as Raw Sienna, Raw Umber or Raw Ochres, due to the presence of iron hydroxide. The chemical colors such as the White Leads, Chrome Yellow, Naples Yellows, Chrome Greens, have a tendency to somewhat bleach the Madder Lakes; Genuine Vermilions, Cadmium Yellows and the Black pigments do not affect them. The Alizarin Madder Lakes yield brilliant and permanent results if applied as a glaze over colors which are thoroughly dry.²¹ Mix alizarin with linseed oil or copal for a glazing medium. Washed or glazed over any color, it lends depth and pulls large parts of a painting together, without obliterating details.²² Permalba with Alizarin or

²¹Ibid., p. 17.

²²Fabri, COLOR, p. 101.

Madder Lake yields tints of highest color value and dependable permanence and durability.

ANTWERP BLUE

Bleu mineral, Bleu d'Anversa, Azul de
Amberes, Antwerpener Blau

Antwerp Blue is a product of iron and zinc cyanogen compounds and yields a color paler than Prussian Blue. Antwerp Blue is a derivative of Prussian Blue. The color strength is weaker than that of Prussian Blue for it has been reduced with Alumina.

The properties of this color are almost identical with those of Prussian Blue (which see).²³

AUREOLIN

Cobalt Yellow, Jaune Indian Aureolin,
Aureolina, Kobaltgelb

It is a yellow crystalline compound salt of the metal Cobalt. It is the Double Nitrite of Cobalt and Potassium-- $\text{Co}_2(\text{NO}_2)_6 \cdot 6\text{KNO}_2$.

The pigment is a pure yellow color, transparent, and slightly soluble in water. If it is not properly washed of soluble salts, it is not absolutely dependable.

²³Weber, ARTISTS' PIGMENTS, p. 19.

It is very fast to air and light, and is unaffected by sulphuretted hydrogen, H_2S , although it is blackened by sodium sulphide and/or caustic soda. Like many other mineral pigments Aureolin when in admixtures with certain organic pigments, such as lakes from cochineal, indigo, etc., causes decomposition of these; the organic colors become altered in hue as also Aureolin itself becomes a brownish hue.

Cobalt Yellow is converted into black cobalt oxide by gently heating in a bunsen flame. Like all cobalt compounds, a blue color is formed when heated with HCl on a platinum wire. This pigment was introduced about 1861.²⁴

AZURE

Sky Blue, Bleu d'Azur, Azul Celeste,
Azurblau, Caeruleus²⁵

The term AZURE is derived through the Romance languages and medieval Latin (lazurius, lazulus, azura), from Arabic al-lazward, and Persian lâjward, the precious blue rock or stone, lapis lazuli (medieval Latin, "blue stone"), from which genuine ultramarine is made.

²⁴Ibid., p. 22.

²⁵Maerz and Paul, DICTIONARY OF COLOR, p. 18.

The term AZURE is, also, a synonym for blue. Azure has been a literary term. For example, Tennyson in "The Brook," had "her eyes a bashful azure," and Shakespeare in "The Tempest," wrote "Twixt the green sea and the azur'd Vault." The name Azure in the past has been attached, for sales purposes to every kind of blue pigment in existence, but this practise has died out.

Because of the very frequent application of the term, in literature and poetry, to indicate the sky or its color, Azure has become synonymous with "Sky Blue."²⁶ The term "Sky Blue" first appeared in 1728.²⁷

Azure is a mixed pigment consisting principally of Ultramarine Blue and Zinc Oxide or Permalba. It yields a warm, light Sky Blue color, contrasting with the cooler greenish Cerulean Blue.

The physical and chemical properties are identical with those of Ultramarine and Zinc White or Permalba.

Azure is fairly opaque and is permanent to light and air.²⁸

BARIUM YELLOW

Permanent Yellow, Barytgelb, jaune

d'outremer, Yellow Ultramarine

²⁶Ibid., p. 149.

²⁷Ibid., p. 181.

²⁸Weber, ARTISTS' PIGMENTS, p. 23.

It is composed of barium chromate. In appearance barium yellow is very little different from zinc yellow, only brighter; under artificial light it is luminously bright, almost white. It is readily soluble in dilute hydrochloric acid, and at the same time turns a reddish yellow. When heated, it becomes reddish, and when cold again, it is pure yellow again. (This is a distinction from zinc yellow). Barium yellow is slightly poisonous, and it is superior to zinc yellow in permanence.²⁹

BLUE-BLACK

Charcoal Black, Vine Black, Frankfort
Black, Noir de Vigne, Rebenschwarz,
Drop Black, Noire bleuatre, Nero
bleustro, Negro azulado,
Frankfurter Schwarz

The active coloring principle is Carbon, in the form of charcoal.

By dry or destructive distillation of grape husks, vine twigs, vine wood and other similar materials, various qualities of Blue-Black are obtained. The finest is Frankford Black, obtained from spent wine yeast, which,

²⁹Doerner, MATERIALS OF THE ARTIST, p. 64.

after carbonizing, is thoroughly washed, to free it from quantities of potash and calcium carbonate derived from the "Tartar" in the wine yeast. Blue-Blacks have little opacity as pigments but are permanent. They are soluble in ordinary solvents and only oxidize at high temperatures, and resist acids and bases like all carbon pigments.

The significant peculiar property of all charcoals in that they withdraw the majority of organic coloring matters from suspension and from solutions in water, is evidenced when a small quantity of Blue-Black is added to a pale tint of Rose Madder in water. The tint becomes rapidly decolorized although not really destroyed, the pigment being completely absorbed by the Blue-Black.³⁰ This property is sometimes made use of in the purification of polluted water.

Charcoal Blacks are mentioned by Pliny in his "Historia Naturalis," A.D. 77, and were perhaps the first pigments used by man.³¹

BLUE-GREEN AND GREEN-BLUE OXIDE

These very permanent and brilliant blue-green pigments are produced by strong calcination of Chromic

³⁰Weber, ARTISTS' PIGMENTS, p. 24.

³¹Ibid., p. 25.

Oxide-- Cr_2O_3 , Aluminum Oxide-- Al_2O_3 , and Cobaltous Oxide-- CoO . The greater amount of Chromic Oxide present will produce a more greenish hue. If a greater quantity of Aluminum Oxide and Cobaltous Oxide are added to the mixture, the color will be more bluish. They are permanent to light, durable, unaffected by alkalies or acids, have no action on other pigments in mixtures,³² and are non-poisonous.³³

BRILLIANT YELLOW

Jaune Brilliant, Amarillo Brillante,
Brillantgelb

Brilliant Yellow resembles Naples Yellow in hue and is prepared by a mixture of Cadmium Yellow, Vermilion, and Permalba. It is opaque, durable, and permanent.³⁴

CADMIUM YELLOW

Cadmium Yellow Lemon or Citron, Light,
Medium and Deep, Cadmium Orange,
Aurora Yellow, Orient Yellow, Daffodil,

³²Ibid., p. 98.

³³Doerner, MATERIALS OF THE ARTIST, p. 84.

³⁴Weber, ARTISTS' PIGMENTS, p. 25.

Sulphide of Cadmium, Jaune de Cadmium,
Giallo di cadmio, Amarillo de cadmio,
Kadmiumgelb

All hues are of the one compound of Cadmium and Sulphur, namely Cadmium Sulphide--CdS.³⁵

The pigments Cadmium Yellow medium, deep and orange consist only of the Sulphide of Cadmium and are the most permanent of the Cadmium Yellows. The lemon or citron and light tints of Cadmium Yellow are usually not the pure sulphide, but the same in combination with flowers of sulphur, zinc or white pigments, and are invariably not quite as permanent as the medium or deeper hues.

The metal Cadmium was discovered by Stromeyer in 1817 and about 1846 the sulphide of Cadmium became recognized as a useful pigment.

By injecting a stream of hydrogen sulphide gas into an acidified solution of a Cadmium salt (Cadmium Chloride or Sulphate in solution) a precipitate of yellow Cadmium Sulphide is obtained, which must be thoroughly washed of any soluble impurities. It is essential that there be no free sulphur present in the pigment. If the pigment has not been obtained by precipitation, but by heating Cadmium Oxide in a covered

³⁵Ibid., p. 28.

crucible with pure Sulphur in excess, an excess of Sulphur is likely to occur. It is necessary that all the chemicals used in making the pigment be absolutely chemically pure, as traces of iron, lead, bismuth, copper or any other metal, giving a colored sulphide, would materially alter the hue and brilliancy of the desired color.

The wet process is in favor industrially in the manufacture of Cadmium Yellows. The Sulphide of Cadmium will vary in hue from light yellow to a fiery orange according to the concentration or strength of the solution of the Cadmium salt, the temperature and the length of ~~time~~ the solution is digested with the hydrogen sulphide gas, and whether the solution be neutral or slightly acidified.³⁶

The darker types of Cadmium, light, medium, dark, and orange, have more covering power and are permanent.³⁷ The paler Cadmiums are more likely to fade slightly.

Cadmium Yellow dissolves in concentrated, hot hydrochloric acid, giving off hydrogen sulphide. A yellow solution would indicate the presence of Chrome Yellow, and a reddish solution would indicate the presence of Zinc Yellow. When heated on a spatula,

³⁶Ibid., p. 29.

³⁷Doerner, MATERIALS OF THE ARTIST, p. 65.

it turns red; upon cooling it returns to yellow.

Heated Cadmium Lemon turned orange within a year.

Cadmium Yellow is not compatible with copper colors such as Emerald Green; in mixture with these it turns permanently black.³⁸ Cadmium Yellow is perfectly safe in admixture with White Lead.

Owing to the cost of chemically pure Cadmium Yellow pigments there is great temptation to adulterate it with either Chrome Yellow, Strontium, Zinc or Barium Chromates. Chrome Yellows being the least expensive are most commonly employed. They can easily be detected by the production of black lead sulphide if the pigment under observation is treated with hydrogen sulphide gas, or a solution of sodium sulphide. Discoloration will not take place if the pigment be pure Cadmium Sulphide.

Cadmium Yellows when mixed with Permalba or Zinc White yield tints closely resembling the true Naples Yellows and are permanent.³⁹

CADMIUM RED is a mixture of Cadmium Sulphide and Cadmium Selenide. It is perfectly permanent to light. Frequently, it is used in place of genuine mercury vermilions on account of its permanency, but it is not as brilliant as the true vermilions.

³⁸Ibid., p. 65.

³⁹Weber, ARTISTS' PIGMENTS, p. 30.

Cadmium Red dissolves to a colorless solution in concentrated hydrochloric acid with the evolution of hydrogen sulphide and hydrogen selenide. Adulteration with barytes would be indicated by an insoluble residue of the same.⁴⁰

CARBON BLACK

Gas Black, Gas Soot, Velvet Black

Noir de charbon, Nero Carbon, Negro de carbon,
Kohlenschwarz

It consists chemically of the element Carbon.

Carbon Black is in all physical respects similar to Lamp Black but is more intensely black in color. Although not crystalline in structure, it has the appearance of such, being granular in form.

In the manufacture of it, Carbon Black differs from the true Lamp Blacks, which are obtained from the combustion of oils, by being made from the combustion of gas. In America, principally in many of the oil regions, the natural gas, which flows out of the ground is utilized for this purpose. The flames are cooled by iron plates on which the soot or carbon black becomes deposited and is collected.

⁴⁰Ibid., p. 31.

Carbon Black is the purest form of the Carbon Blacks, e.g. Ivory Black, Lamp Blacks, and Charcoal Blacks, and like these resists acids and bases, is absolutely permanent and adaptable to all techniques.⁴¹ Only at exceedingly high temperatures the carbon unites with oxygen in the air, yields the gas, carbon dioxide, and leaves no ash residue. Being an extremely poor drier in oil, it retards drying of admixtures with other colors. On account of its tinctorial strength, Carbon Black stains every other color with which it may be mixed.⁴²

CERULEAN BLUE

Coeruleum, Bleu celeste, Coerulium,
Coelinblau, Blue ceruleum,
Azul celeste

It consists of a compound of Cobaltous Oxide--
CoO--and Tin Oxide--SnO₂.

This light greenish-blue pigment is permanent, almost opaque, and adaptable to all techniques. It is safe to mix with any pigment but has a limited tinting power.

It is usually obtained by precipitating a solu-

⁴¹Ibid., p. 32.
⁴²Ibid., p. 33.

tion of Cobalt Chloride-- CoCl_2 --with potassium stannate, thoroughly washing the precipitate and then mixing it with pure silica and heating. Another method is to moisten Tin Oxide-- SnO_2 --with a Cobalt Nitrate solution, strongly heating, then powder and wash the greenish-blue mass which is the variety of Cerulean Blue known as COERULEUM.⁴³

Cerulean Blue does not acquire a violet cast as other cobalt blues do. A permanent imitation of Cerulean Blue can be made by mixing Cobalt Blue, Viridian, Zinc White or Permalba together. It is practically unaffected by weak acids and alkalies.⁴⁴

It was introduced as a pigment in 1859.⁴⁵

CHROME GREEN

Chrome Green light, medium, and deep,

Zinnober Green, Cinnabar Green,

Zinc Green, Green Vermilion,

Cinabro Verde, Cinabre vert,

Cinabrio verde

Chrome Green is a mixture of Prussian Blue and Chrome Yellow pigments. By varying the amounts, the

⁴³Ibid., p. 35.

⁴⁴Ibid., p. 36.

⁴⁵Maerz and Paul, DICTIONARY OF COLOR, p. 181.

hue obtained will range from pale yellow-green to deep blue-green.

These Chrome Greens should not be confused with Chromium Greens, namely the transparent hydrated Oxide of Chromium (Emeraude Green) or opaque Oxide of Chromium.⁴⁶

Chrome Green is opaque and fairly permanent to light. Acids cause the color to become more blue in hue. The acids dissolve out the chrome yellow. Alkalies turn it orange. The alkalies change the blue coloring of the pigment to a reddish-brown and the yellow coloring of the pigment to an orange. Sulphurous gases or sulphur darken the Chrome Green considerably.⁴⁷

Chrome Green was introduced as a pigment in 1815.⁴⁸

CHROME RED

Chromrot, rouge de chrome

It is basically Lead Chromate-- PbCrO_4 ~~PbO~~.

It is similar to Chrome Yellow and dries quickly. Acetic acid changes it to yellow. Chrome Red is a good example for showing the effect of the size of the grain on the character of the color. When finely ground, the color becomes lighter and more of a yellowish red. It

⁴⁶Weber, ARTISTS' PIGMENTS, p. 37.

⁴⁷Ibid., p. 38.

⁴⁸Maerz and Paul, DICTIONARY ON COLOR, p. 192.

should be worked only with the spatula and just before being used.⁴⁹

CHROME YELLOW

Chrome Yellow light, medium, and deep,
 Chrome Lemon, Chrome Orange,
 Chrome Red, Paris Yellow,
 Kings Yellow, Jaune de Chrome,
 Giallo di cromo, Amarillo de cromo,
 Chromgelb

The pure rich chrome yellow hue is Neutral Lead Chromate-- PbCrO_4 ; the paler tints and lemon or citron chromes are mixtures of Lead Chromate and Lead Sulphate; the orange hues are Basic Lead Chromate-- $\text{PbCrO}_4 \cdot \text{PbO}$.

The Chrome Yellows (neutral lead chromate) are all obtained as precipitates by the addition of a solution of a soluble lead salt to a solution of a soluble chromate or bichromate. A solution of lead acetate is brought together with a solution of potassium chromate or bichromate, yielding a precipitate of Chrome Yellow.

⁴⁹Doerner, MATERIALS OF THE ARTIST, p. 75.

This must be thoroughly washed free of potassium acetate, which is formed and stays in solution.⁵⁰

During precipitation of lead chromate, an addition of sulphuric acid yields paler lemon or citron hues. Alum and Blac Fixe (BaSO_4) are, also, used to make paler Chrome Yellows.

By treating yellow lead chromate with a weak solution of sodium or potassium hydroxide (caustic soda or potash), which removes some of the chromate radical of the lead chromate, basic lead chromate, which is orange yellow to orange red in hue, is formed. Chrome Orange and Chrome Red can be obtained by precipitation from solutions of lead acetate, litharge, and neutral potassium chromate; sometimes, with the addition of caustic potash a deeper, redder hue is obtained.⁵¹

Chrome Yellow colors are brilliant and inexpensive. It covers and dries well. A little bit of it when used goes a long way. The lighter tones do not stand up well under light; even as a powder they turn a dirty leather color and in oil a dirty greenish brown. The darker shades of Chrome Yellow are, according to their degree of darkness, more permanent. It must be given an addition of wax, 2%, or it is apt to harden in the tube. The pigment is mixed with 25% poppy oil.⁵²

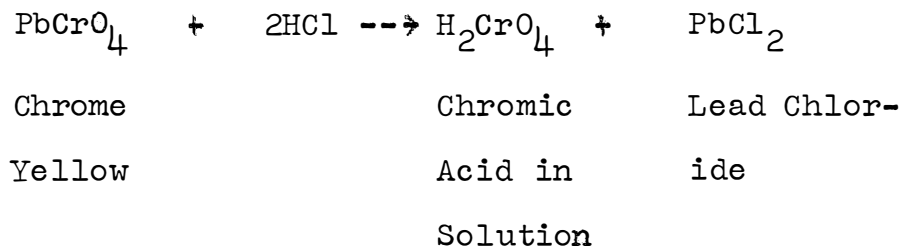
⁵⁰Weber, ARTISTS' PIGMENTS, p. 39.

⁵¹Ibid., p. 40.

⁵²Doerner, MATERIALS OF THE ARTIST, p. 63.

When mixed with pigments of organic origin, especially those which themselves are prone to oxidize, Chrome Yellow has a tendency to undergo reduction: the loss of oxygen by its chromate radical, yielding the green or lower oxide of Chromium.

Hydrochloric acid decomposes Chrome Yellow, yielding a solution, reddish-yellow in color (free of chromic acid) and a residue of white lead chloride:



The diluted solution of reddish-yellow Chromic Acid, if alcohol be added, will turn green in color upon warming, and produce an agreeable aldehyde odor: the smell of apples. The white precipitate of Lead Chloride will dissolve in an excess of hot water, in which the presence of lead can be detected with sodium sulphide (the formation of black lead sulphide).

Lyes decompose Chrome Yellow with the formation of yellow colored solutions of alkali chromates. Ammonia dissolves Chrome Yellow, yielding a yellow solution. Caustic soda, not in excess, changes Chrome Yellow to an orange color. Heated with carbon, it is converted into

metallic lead.⁵³ When heated, Chrome Yellow becomes a reddish-brown. When cold again, it is a dirty yellow.⁵⁴ Impure pigments containing free sulphur will darken Chrome Yellow to a dark brown or gray color.

Chrome Yellow was discovered about 1797 but evidence of its use as a pigment does not appear until early in the nineteenth century.⁵⁵

COBALT BLUE

Blue de Thenard, Kings Blue,
Bleu de cobalt, Bleu Cobalto,
Azul de Cobalto, Kobaltblau

It is a compound made of Cobaltous Oxide-- CoO , and Aluminum Oxide-- Al_2O_3 --in the presence of phosphoric acid; arsenic acid or Ainc Oxide, to yield different hues.

According to the method employed in its manufacture, Cobalt Blue is a mixture of either oxide, phosphate or arsenate of Cobalt with aluminum oxide yielding a deep blue tending towards a violet color. Optically Cobalt Blue reflects a considerable amount of green and violet light, in consequence of which it acquires a purplish hue when examined by artificial

⁵³Weber, ARTISTS' PIGMENTS, p. 41.

⁵⁴Doerner, MATERIALS OF THE ARTIST, p. 63.

⁵⁵Weber, ARTISTS' PIGMENTS, p. 42.

light, particularly by gas or candle light.

The usual Cobalt Blues of violet hue are compounds of Cobaltous Oxide and Aluminum Oxide. Variable amounts of Zinc Oxide added to the admixture yield a pure greenish-blue. This hue varies according to the quantity of Zinc Oxide present. By heating at high temperatures an intimate mixture of Aluminum Oxide, or Alumina (Aluminum Hydrate) with Cobalt carbonate, phosphate, or arsenate, the pigment Cobalt Blue is obtained. Alumina in excess will produce lighter tints.⁵⁶

It is a non-poisonous metal color that is unaffected by acids, alkalies, and heat. It is light-proof and permanent. The color requires 100% oil but dries quickly. Because of this drying power cobalt often causes cracks in paintings when put over coats of paint which are not yet sufficiently dry.⁵⁷

Cobalt Blue first appeared as a pigment in 1777.⁵⁸

COBALT GREEN

Rinmann's Green, Vert de Cobalt,
Verde di Cobalt, Verde de Cobalto,
Kobalt Gruen

⁵⁶Ibid., p. 46.

⁵⁷Doerner, MATERIALS OF THE ARTIST, p. 80.

⁵⁸Maerz and Paul, DICTIONARY OF COLOR, p. 193.

It is a compound of Cobaltous Oxide--CoO, and Zinc Oxide--ZnO.

It is formed when Cobalt Oxide and Zinc Oxide are heated at high temperatures. Paler tints require greater amounts of Zinc Oxide.

Genuine Cobalt Green is permanent, semi-transparent pigment. The deeper shades are more transparent. It will not decompose at moderately high temperatures.⁵⁹

The color appears in the trade in yellowish and bluish tones. It has not much coloring strength, is somewhat gritty, and does not adhere well. Cobalt Green dries quickly; despite its poor coloring strength but because of its fine, cool tones, it is used for flesh tints.⁶⁰

Hydrochloric acid dissolves Cobalt Green to a rose-red solution and forms chlorides of cobalt and zinc.

Cobalt Green was discovered by a Swede, Rinmann, in 1780.

COBALT VIOLET

Cobalt Violet light and deep,
Cobalt Red, Violet de Cobalt,

⁵⁹Weber, ARTISTS' PIGMENTS, p. 47.

⁶⁰Doerner, MATERIALS OF THE ARTIST, p. 86.

Violetto cobalto, Cobalto violeta,

Kobalt violet

The dark cobalt violet, Anhydrous Cobalt Phosphate-- $\text{Co}_3(\text{PO}_4)_2$ --is very permanent, transparent and has little tinting strength or brilliancy.

It is not acted upon by acids or bases, and heat will not destroy it. It is insoluble in ordinary solvents and is not discolored by sulphurous gases.

By precipitating a solution of any soluble Cobalt salt with a solution of Disodium Phosphate-- $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ --and thoroughly washing and drying the precipitate and heating it to a high temperature, yields the pigment Cobalt Violet. Pigments consisting of Cobalt and Magnesium Oxides prepared at high temperatures yield a more reddish hue, Cobalt Red.⁶¹

Cobalt Violet was introduced as a pigment in 1859 by Salvetat.⁶²

CYANEOUS

Cyanine, Leitch's Blue

The term CYANEOUS is derived from ancient Greek, CYANOS. Homer was one of the earliest users of this term,

⁶¹Weber, ARTISTS' PIGMENTS, p. 48.

⁶²Ibid., p. 49.

employing it in various forms, forty-five times in the ILIAD and the ODYSSEY, with the general meaning of "dark blue," and sometimes, poetically, of merely "dark."⁶³

Today Cyaneous is referred to by the term CYANINE. It is a mixture of Cobalt Blue and Prussian Blue.

This semi-transparent color is practically permanent. The Cobalt Blue constituent by the admixture seems to protect the Prussian Blue from change, by absorbing some of the active (actinic) rays of light.⁶⁴

DELFT BLUE

The name is due to the fact that the potters in the city of Delft, Holland, about the beginning of the eighteenth century, first succeeded in imitating this particular color, found in chinaware imported from China. It was then called "Oriental Blue."⁶⁵

It is a semi-opaque hue obtained from the admixture of Prussian Blue (or Antwerp Blue), Lamp Black, and Ultramarine. It is permanent.⁶⁶

⁶³Maerz and Paul, DICTIONARY OF COLOR, p. 155.

⁶⁴Weber, ARTISTS' PIGMENTS, p. 51.

⁶⁵Maerz and Paul, DICTIONARY OF COLOR, p. 155.

⁶⁶Weber, ARTISTS' PIGMENTS, p. 52.

EMERALD GREEN

Paris Green, Vert Paul Veronese,
 Schweinfurt Green, Mitis Green,
 Veronese Green, Cenere verde,
 Vert cendre, Verde ceniza,
 Mineral Green, Swedish Green,
 Scheeles Green,⁶⁷ Smargdgrun,
 Smaragdinus⁶⁸

Emerald Green consists of Cupric Aceto-Arsenite
 $--(\text{CuOAs}_2\text{O}_3)_3 \cdot \text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$.

In 1814 while experimenting to improve Scheeles Green (copper arsenite) (also called Mitis Green and Veronese Green) named after its discoverer, the eminent Swedish chemist Scheele in 1778, the much more brilliant and more permanent Schweinfurt Green (Emerald Green) was developed at the color works of W. Sattler at Schweinfurt, from which it receives its name.⁶⁹

It is the most poisonous and dangerous of all pigments. The color is a luminous bluish and/or yellowish green. It is permanent, but incompatible with sulphur colors, such as cadmium yellow, vermilion, and ultramarine. Discoloration ensues quickly, and the paint becomes black. It requires but little oil, 30%,

⁶⁷Ibid., p. 53.

⁶⁸Maerz and Paul, DICTIONARY OF COLOR, p. 19.

⁶⁹Weber, ARTISTS' PIGMENTS, p. 53.

in preparation as an oil pigment. It dries well.⁷⁰

Emerald Green is entirely soluble in boiling hydrochloric acid or nitric acid or ammonia. It should have no precipitate when barium chloride is added to the clear solution. When treated with Acid Potassium Ferrocyanide, Emerald Green will discolor brownish. Hydrogen Sulphide gas, H_2S , as also Sodium Sulphide will decompose the copper green with the formation of black copper sulphide.⁷¹

Ammonium hydroxide dissolves Emerald Green to a deep blue colored solution. This is a characteristic test for all copper pigments.

If a small piece of metallic zinc is added to hydrochloric acid which an amount of Emerald Green has been dissolved, evolves the extremely poisonous gaseous ARSINE (AsH_3), which can be recognized by its garlic-like odor. If this test must be made, use extreme caution.⁷²

INDIAN RED AND RED IRON OXIDES

Rouge indien, Rosso indiano, Rojo indiano,

Indischrot, Caput mortum, Colcothar,

Rouge, Iron Oxides deep and violet,

⁷⁰Doerner, MATERIALS OF THE ARTIST, p. 83.

⁷¹Weber, ARTISTS' PIGMENTS, p. 54.

⁷²Ibid., p. 55.

Persian Red, Tuscan Red, Pompeian Red,
 Venetian Red, Rouge de Venise,
 Rosso di Venezia, Rojo de Venecia,
 Venezischrot, Terra Pozzuoli

It is Basic Ferric Oxide-- Fe_2O_3 .⁷³

The native mineral Haematite (Red Iron Stone or Blood Stone) or red ochre has been the source of supply of Ferric Oxide since ancient times. Ferric Oxide is nearly chemically pure in this. It is composed of 95% Ferric Oxide.

The natural red iron oxides are dark in hue when pure. They are as equally as permanent and dependable as artificially prepared substitutes.

It is obtained by two processes: the Dry Process and the Wet Process. In the Dry Process, Copperas (Ferrous Sulphate-- $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) is heated to yield pure Ferric Oxide-- Fe_2O_3 . By regulating the temperature at which calcination is carried on and its duration, the hue will vary from bright red by moderate heat, to a deep purplish hue by white heat.⁷⁴

To test for the presence of iron sulphates in the pigment, moisten the pigment with water and heat it to glowing in the test tube. The moisture which condenses on the cooler wall of the test tube, should not

⁷³Ibid., p. 64.
⁷⁴Ibid., p. 65.

turn blue litmus paper red.

In the Wet Process, by-products of iron compounds are utilized. Iron is precipitated from solution and calcined and yielded, as in the Dry Process, varying hues of Iron Oxides red.

In the hydrated form, Ferric Oxide represents the active coloring principle of native ochres, sienhas, and umbers, which when calcined give up their water of hydration to yield the Ferric Oxide, changing in hue from yellow or brown to a warm red.

Red Oxides are not altered by moderate heat and should not yield a tarry distillate on the walls of a test tube when heated to glowing. It is insoluble in water and alcohol, is safe, permanent, and indifferent to alkalies. The deeper hues are more resistant to acids. A mixture of Zinc White or Permalba and Indian Red yields a reliable flesh tint.⁷⁵

If the pigment is ground too fine in oil, "bleeding" will occur. It requires from 40-60% oil. Indian Red possesses good covering power and dries fairly well.⁷⁶

INDIAN YELLOW

Piuri, Purree, Jaune indien,
Giallo indiano, Amarillo indian,

⁷⁵Ibid., p. 66.

⁷⁶Doerner, MATERIALS OF THE ARTIST, p. 71.

Indischgelb

Indian Yellow is a natural organic lake. It is an impure Magnesium and Calcium Salt of Euxanthic Acid



Genuine Indian Yellow is obtained from the urine of cows that are principally fed on mango leaves. This food stimulates the secretion of bile, and the excess of which strongly colors the urine. The bright yellow urine is boiled down in earthen vessels, yielding a yellow mass, which is strained through material, e.g. calico, and formed into balls and put on the market in this shape. The crude round balls of pigment are about three or four inches in diameter, are of a dirty greenish to brown color externally and internally of a bright yellow hue. It has a ammonical, urinous odor and is non-poisonous.

About two ounces of Purree is obtained daily from one cow producing three-fourths of a gallon of urine. It is made exclusively at Monghyr in Bengal by the tribe of people known as Gwalas.

The coloring principle, the salt of euxanthic acid, is not present alone in the natural pigment. Foreign mineral and organic matters are, also, present. This raw material, Purree, is first freed from the brown earthly crustation, and is washed thoroughly in boiling water until the water filtered from it comes off clear showing no brownish discoloration. With this treatment the brown

colored impurity and odor are lost. It is then dried, powdered, and used in this condition.⁷⁷

It is a beautiful golden yellow glazing color which is quite permanent. If a small piece of Indian Yellow color, is boiled in water and hydrochloric acid is then added, the yellow color will immediately disappear. Like many organic substances, it should leave an ash when burned, but this should be white. The ash that is left is completely soluble in hydrochloric acid.

Indian Yellow is a very expensive pigment.⁷⁸

The earliest record of its use as a pigment is 1735.⁷⁹

LAMP BLACK

Noir de bougie, Nero fume,
Negro de humo, Lampenschwarz,
Vegetable Black

It is a flocculent black form of commercially pure Carbon--C.

Lamp Black is a fine flocculent kind of soot obtained from wick lamps in which oils rich in carbon are burnt with insufficient air for complete combustion. The soot, which is deposited on plates held into the flame,

⁷⁷Weber, ARTISTS' PIGMENTS, p. 67.

⁷⁸Doerner, MATERIALS OF THE ARTIST, p. 66.

⁷⁹Maerz and Paul, DICTIONARY OF COLOR, p. 197.

is collected and is ready for commercial use. The better varieties are obtained from fluid fatty oils.

Lamp Black is of strong black color with considerable opacity, is permanent, is unaffected by impure air, gases, acids or alkalies and is insoluble in all usual solvents.

It is a slow drier in oil.⁸⁰

MALACHITE GREEN

Green Verditer, Green Copper Carbonate,

Mountain Green, Green Bice,

Vert de Moutagne, Mineral Green,

Verde minerale, Vert mineral,

Berggruen, Malachitgruen,⁸¹

Verde Azuro⁸²

This pigment has been in use for over 3000 years. It is the oldest know GREEN pigment. Traces of it have been found in ruins in Pompeii, Rome, and Egypt.⁸³ From ancient times to the Renaissance, it bore the Greek name CHRYSOCOLLA.⁸⁴

⁸⁰Weber, ARTISTS' PIGMENTS, p. 79.

⁸¹Ibid., p. 87.

⁸²Cennino D'Andrea Cennini, IL LIBRO DELL' ARTE, (The Carftsman's Handbook), trans. by Daniel V. Thompson, Jr., (New York: Dover Publications, Inc., 1933), p. 31.

⁸³Weber, ARTISTS' PIGMENTS, p. 88.

⁸⁴Maerz and Paul, DICTIONARY OF COLOR, p. 165.

It is composed of Basic Copper Carbonate--
 $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$. It is found native in America, Asia,
 Africa, and Europe.

Malachite-- $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ --is formed gradu-
 ally out of blue carbonate, Azurite-- $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$.
 The two are often found blended into a single sample
 of ore.

It is readily blackened when it comes into con-
 tact with sulphurous gases or sulphur compounds and
 fades slightly when exposed to strong light. Admix-
 tures with Cadmium Yellows, Aurora Yellow, Ultramarine,
 and genuine Vermilions should be avoided.

As an oil it is permanent, especially if it
 is protected by a strong varnish film.⁸⁵

It is soluble in acids, with effervescence to
 a clear solution, and will turn to a deep blue color
 upon addition of ammonia water in excess.

Heat destroys the pigment and forms black copper
 oxide.

MANGANESE VIOLET

Mineral Violet, Permanent Violet,

Nuernberger Violet

⁸⁵Weber, ARTISTS' PIGMENTS, p. 87.

It is a double salt of Phosphuric Acid with Manganese and Ammonium.

Its violet hue is more true than the reddish Cobalt Violet.

The three principal permanent violet pigments are: Manganese Violet, Cobalt Violet, and Violet Ultramarine.

To obtain the pigment Manganese Violet, melt Manganese Dioxide and Ammonium Phosphate together. The Ammonia will evolve and yield a fused mass of violet color, which is digested with Phosphoric Acid and heated until a rich violet hue is produced. After cooling, wash with water and Phosphoric Acid, until the residue pigment which remains is no longer soluble in water.

Manganese Violet is soluble in hydrochloric acid; chlorine will evolve. It is permanent to light and is safe.⁸⁶

A test for this pigment is made by melting a sample of the color in question with soda on a porcelain dish, or a platinum wire. A bright green molten mass of Sodium Manganate (Na_2MnO_4) is produced. It is soluble in water and discolours the solution green. After standing for some time this bright green color will change to

⁸⁶Ibid., p. 88.

a violet color. Sodium Permanganate-- NaMnO_4 --is formed.⁸⁷

The earliest record of its use as a pigment was in 1873.⁸⁸

MARS COLORS

Mars Brown, Mars Orange,

Mars Red, Mars Violet,

Mars Yellow

They are artificial ochres. Their color is derived from the Hydrate and Oxide of Iron.

Mars Yellow is obtained by precipitating a salt of iron with alumina by means of either caustic lime, soda, or potash. The more alumina used the paler the product. Mars Yellow when subjected to calcination yields depending upon duration and degree of heat under which the process is being carried on, different hues are obtained: Mars Brown, Orange, Red, and Violet.

They are no more permanent or brilliant than the native ochres or natural iron reds.⁸⁹ Mars colors are more transparent because they contain less clay and are disproportionately expensive. They are more uniform in color than natural ochres.⁹⁰

⁸⁸Maerz and Paul, DICTIONARY OF COLOR, p. 198.

⁸⁹Weber, ARTISTS' PIGMENTS, p. 89.

⁹⁰Doerner, MATERIALS OF THE ARTIST, p. 69.

Mars Colors were introduced as pigments in
1835.⁹¹

NAPLES YELLOW

Jaune de Naples, Jaune d'Antimoine,
Giallo di Napoli, Amarillo de Napoles,
Neapelgelb

Naples Yellow consists mainly of Lead Antimoniate-- PbSb_2O_6 .

It was used as an enamel and on decorated pottery. There is record of it being secretly manufactured in Naples about 1760.

Naples Yellow is obtained by prolonged roasting of finely mixed oxides of lead and antimony with the addition of tin oxide to the mixture before roasting. It will yield a Naples Yellow of a rich light yellow hue.

It is permanent to light and air, is very opaque, has little tinting strength, and dries well in oil.

When it comes into contact with a metallic iron or tin or zinc, Naples Yellow becomes gray. It is advisable to use a horn or wooden spatula in preparing and/or mixing the pigment.

Hydrochloric acid and nitric acid slowly dissolves the pigment. The resultant solution is colorless. Alka-

⁹¹Maerz and Paul, DICTIONARY OF COLOR, p. 198.

lies decompose it.

Today, Naples Yellow is imitated. The admixture of Cadmium Yellow, Permalba, Zinc White, and light Red or Venetian Red yields a color of Naples Yellow and of excellent permanency.⁹²

OCHRES, NATURAL AND CALCINED

Ochres are a variety of natural earths; the basic coloring principle is Iron Oxide--Ferric Oxide-- Fe_2O_3 --and various iron hydroxides.

The word Ochres is from ancient Greek OCHROS. It was used in Homer, along with the word CHLOROS to express the pallor of the face from fear in battle. CHLOROS implied a greenish tinge and later came to denote a bright green. OCHROS was used strictly for yellowish tones. Soon after the time of Homer, the term OCHROS was applied to the yellowish native earth containing silica, alumina, and ferric oxide, better known as CLAY rather than EARTH. It is one of the oldest pigments known.

The word Ochre is a generic term, and in consequence, many defining adjectives have been prefixed to it in order to identify certain distinctive grades, usually according to variation in color. From the very

⁹²Weber, ARTISTS' PIGMENTS, p. 91.

early days, the word OCHRE was sometimes used alone, but was practically always intended to refer to the pigment more exactly known as Yellow Ochre.⁹³

NATURAL YELLOW AND BROWN OCHRES

The yellow and brown ochres derive their color from the presence of iron hydroxides. There are several iron hydroxides, which exist as mineral species. The Yellow and Brown Ochres derive their color, principally from three of these, Yellow Haematite, XANTHOSIDERITE-- $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$; Brown Haematite, LIMONITE-- $2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ and Bog-iron ore, LIMONITE-- $\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$. These ochres are composed of either or several of these hydroxides in varying amounts, together with more or less clay, sand, chalk, gypsum, barytes and occasionally silica, diatomaceous in nature. This varying composition greatly influences the color, tinting strength, opacity and purity of the ochre. The ochres selected for artists' pigments are from France, Italy, Germany and Spain even though ochres are found in every country of the world. The ochres with the larger percentages of iron hydroxides are more transparent and of stronger color than those which contain large amounts of clay or other bituminous organic matter. The ochres that contain large amounts

⁹³Maerz and Paul, DICTIONARY OF COLOR, p. 169.

of clay and bituminous organic matter are opaque, dull and of weak color.

It is necessary to thoroughly wash and levigate natural ochres before their use as artist pigments thereby washing the color free of sand and any soluble salts, which would otherwise be of considerable detriment, affecting their durability as pigments.

When pure, all ochres rank high with the most durable and permanent pigments.

Hydrochloric acid dissolves the iron from ochres yielding a yellow solution (iron chloride), the remaining undissolved sediment is composed of clay and other earthly substances.⁹⁴ Ochres to which dyes or lakes have been added to brighten the color, usually bleed these admixtures in alcohol to which a little ammonium hydroxide is added. Ochres when heated in a test tube should not yield a tarry condensation on the cool side of the tube. Ochres should be insoluble in boiling water.

Mixtures of the natural ochres with organic pigments and lake colors are best regarded as of uncertain stability, the iron hydroxides have a tendency to reduce these colors.

The Yellow and Brown Ochres appear under the fol-

⁹⁴Weber, ARTISTS' PIGMENTS, p. 93.

lowing names: YELLOW OCHRE, Ocre jaune, Ocria gialla, Ocre amarillo, Lichter Ocker, Transparent Golden Ochre, Ocre d'or transparent, Ocria dorata, Ocre de oro, Gold-ocker, Golden Ochre, Roman Ochre, Ocre de Rome, Ocria di Roma, Ocre de Roma, Ocker roemisch, Brown Ochre, and Oxford Ochre.

NATURAL RED OCHRES

The natural red ochres are of similar composition containing a greater percentage of iron oxide. The additional iron oxide gives the characteristic red color to the ochre.⁹⁵

The natural red ochres are prepared in the same manner as the natural yellow ochres. The most durable and permanent pigments are obtained by thorough washing and levigation of the minerals.

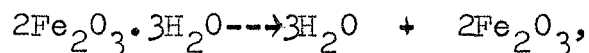
To these colors belong the genuine Indian Red, Venetian Red, Terra Pozzuoli, Terra Rosa, Red Chalk, Bole, Ruddle, Red Iron Ore, Red Haematite, and Bolus. Sinopis and Rubica were red ochres that were used in ancient times.

CALCINED OR BURNT OCHRES

When natural ochres are roasted, the iron hydroxides lose their water content and are converted into

⁹⁵Ibid., p. 94.

iron oxide,



thereby causing a change of color from yellow to red.

The different varieties of yellow ochres yield upon calcination products varying in color from orange-red to deep red-brown. The resultant hue is also affected by the temperature during roasting. The calcined ochres are as permanent as the raw ochres.

The following colors belong to the burnt ochres: Light Red, Brun rouge, Bruno rosso, Pardo rojo, Burnt Ochre, Ocria bruciate, Ocre brûlée, Ocre tostado, Gebrannter Ocker, Burnt Roman Ochre.⁹⁶

OXIDE OF CHROMIUM, OPAQUE

Chromic Oxide, Oxyde vert de chrome,

Ossido di cromo verde,

Oxido de cromo verde,

Gruenes Chromoxyd

It consists of the green oxide of Chromium,
Chromic Oxide-- Cr_2O_3 .

It was first introduced by Vauquelin in 1797.

It is of dull green color varying in hue, depth and opacity according to the process, wet or dry, and

⁹⁶Ibid., p. 95.

conditions under which it was produced.

It is very stable and inert in mixtures, permanent, and employed as a vitrifiable pigment in the enameling of pottery.⁹⁷ It requires 30% oil and dries no faster than Oxide of Chromium, Transparent.

The Oxide of Chromium greens can be distinguished from its substitutes for their ability to withstand the action of acids and alkalies.⁹⁸

Sodium Sulphide and Hydrogen Sulphide do not affect this pigment.⁹⁹

OXIDE OF CHROMIUM, TRANSPARENT

Emeraude Green, Viridian, Vert emeraude,

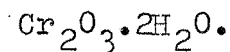
Verde smeraldo, Verde esmeralda,

Feuriges Chromoxyd, Guignet Green,

Emerald Oxide of Chromium,

Pannetiers Green, Mittlers Green

It is composed of Hydrated Chromic Oxide--



In 1834, Pannetier produced by a secret process the brilliant Chrome Green, which several years later was manufactured by the patented process of M. Guignet,

⁹⁷Ibid., p. 96.

⁹⁸Doerner, MATERIALS OF THE ARTIST, p. 84.

⁹⁹Weber, ARTISTS' PIGMENTS, p. 97.

whose method is still in use today.

This pigment is produced by thoroughly mixing and calcining eight parts of boracic acid with three parts potassium bichromate, treating the resultant fused mass of green color with cold water, washing it by decantation, grinding the wet decantant, washing it with hot water to free any soluble salts (potassium borate) and then carefully drying it.

Oxide of Chromium, Transparent is the one of the most desirable and valuable pigments: excellent tinting strength; color depth; transparent; durable; unalterable in all techniques; unaffected by sulphurous gases, dilute acids or alkalies; and is permanent to light.¹⁰⁰

It is non-poisonous. It dries well and should not lose any of its color in water, alcohol, or ammonia. If it does, it shows adulteration with a coal-tar dye. The color of the Oxide of Chromium, Transparent, requires much oil, 100%, and must be allowed to stand for a few hours after grinding, when it will again almost absorb as much pigment as before. Two percent of wax is needed and should be added to the color in its preparation as an oil.¹⁰¹

PERMANENT

¹⁰⁰Ibid., p. 98.

¹⁰¹Doerner, MATERIALS OF THE ARTIST, p. 84.

Permalba is a true composite pigment consisting essentially of a compound of Barium Sulphate.

Permalba is an artists' Permanent White introduced by F. W. Weber Company of Philadelphia, Pennsylvania.

It is absolutely permanent to light; is unaffected upon exposure to impure air, dampness, and gases; is most opaque white pigment with the greatest tinting strength; will not discolor with age; is chemically stable and inert towards other pigments; is not acted upon or does not react with any vehicles or mediums used in painting; does not contain lead or zinc; is non-toxic; is acid and alkali resistant; is not discolored by sulphur gases or compounds; yields tints of exceptional brilliancy; has true color value when mixed with any color; withstands high baking temperatures without discoloration; photographs white; and is not acted upon or altered by actinic light rays.

Permalba, when ground in pure oil, yields upon oxidation (drying), an elastic film which has no tendency to crack, to become horny, or to become brittle.¹⁰²

PRUSSIAN BLUE

Bleu de Prusse, Bleu di Prussia,

¹⁰²Weber, ARTISTS' PIGMENTS, p. 99.

Azul de Prusia, Preussischblau,
 Paris Blue, Chinese Bleu, Milori Blue,
 Bronze Blue, Steel Blue, Mineral Blue,
 American Blue,¹⁰³
 Louise Blue,¹⁰⁴ Berlin Blue

Berlin Blue was the original name; Prussian Blue came much later. The substance was discovered in 1704¹⁰⁵ by Diesbach in Berlin.¹⁰⁶ It was first introduced in Germany in 1710, under the name of Berlin Blue, and in England in 1724.¹⁰⁷

It is composed of Ferric Ferrocyanide-- $\text{Fe}_4(\text{Fe}(\text{CN}_6))_3$ --a complex compound of iron and cyanogen.

CYANOGEN is composed of carbon united with nitrogen--CN--and is known to constitute one of the most powerful poisons when in the simple compound of Potassium Cyanide--KCN. Prussian Blue is not poisonous.

When solutions of Yellow Prussiate of Potash (Potassium Ferrocyanide)-- $\text{K}_4\text{Fe}(\text{CN})_6$ --and iron (Ferric salts) are brought together, keeping the iron salts in excess, Prussian Blue (Ferric Ferrocyanide) is formed

¹⁰³Ibid., p. 100.

¹⁰⁴Maerz and Paul, DICTIONARY OF COLOR, p. 165.

¹⁰⁵Ibid., p. 175.

¹⁰⁶Weber, ARTISTS' PIGMENTS, p. 100.

¹⁰⁷Maerz and Paul, DICTIONARY OF COLOR, p. 175.

as a deep blue insoluble precipitate.

If during precipitation the potassium ferrocyanide is kept in excess, a deep blue precipitate is formed which is soluble in water. This compound is composed of iron, cyanogen, and potassium. It is called Soluble Prussian Blue. By treating the insoluble Prussian Blue with Glauber Salt (Sodium Sulphate) and Oxalic Acid, a soluble Prussian Blue is obtained.

Ferrous salts, e.g. Iron Vitriol--Ferrous Sulphate--and Yellow Prussiate of Potash form a white precipitate¹⁰⁸ when exposed to air or if treated with Nitric Acid and is oxidized thereby developing Prussian Blue. Owing to the cheapness of Iron Vitriol (Copperas) this method is usually employed for commercial manufacture of Prussian Blue.

Chalk, Gypsum, Clay, and Starch are often added to Prussian Blue as adulterants and to lighten the color and weaken its tinting strength.¹⁰⁹ Antwerp Blue and Milori Blue are adulterated products of Prussian Blue.¹¹⁰

Prussian Blue is a very transparent color and has a powerful tinting strength, is insoluble in water, has a bronzy appearance when dry, has a tendency to fade

¹⁰⁸Weber, ARTISTS' PIGMENTS, p. 101.

¹⁰⁹Ibid, p. 102.

¹¹⁰Derner, MATERIALS OF THE ARTIST, p. 81.

slightly when put into the sun but regains its color when restored to the dark, and is sensitive to alkalis.¹¹¹

Prussian Blue is a beautiful deep blue color especially when it is mixed with white, but it is so powerful that it "kills" every color with which you mix it, even though it is transparent. Like asphaltum, it rises to the surface gradually, and where you had intended to have a slight Prussian Blue tone, you find a dark blue spot. This pigment is hard to use.¹¹²

Prussian Blue is almost instantaneously discolored by potassium hydroxide. Although it dries well as an oil, the pigment takes up a lot of oil, 80%, in preparation.¹¹³

By roasting Prussian Blue, it is oxidized to brown iron oxide and is known as Prussian Brown. Weak acids do not affect Prussian Blue. Solutions of Red Prussiate of Potash (Potassium Ferricyanide)-- $K_3Fe(CN)_6$ --when added to solutions of ferrous compounds, yield a blue insoluble precipitate, Ferrous Ferricyanide-- $Fe_3(Fe(CN)_6)_2$ --Turnbull's Blue. Blue Prints owe their color to the formation of Turnbull's Blue.¹¹⁴

¹¹¹Weber, ARTISTS' PIGMENTS, p. 102.

¹¹²Fabri, COLOR, p. 103.

¹¹³Doernenr, MATERIALS OF THE ARTIST, p. 81.

¹¹⁴Weber, ARTISTS' PIGMENTS, p. 103.

RED LEAD

Minium, Orange Mineral,

Saturn Red, Paris Red,

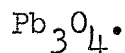
Rosso di Saturno,

Minio, Mennige,¹¹⁵

Miniatus,¹¹⁶

Bleimennige¹¹⁷

It consists of a bright red Oxide of Lead--



Red Lead is produced by heating Litharge (lead monoxide-- PbO) in the presence of air. The finest variety of Orange Mineral is obtained by carefully heating pure White Lead, which is converted into Litharge and then into Red Lead.

In dry powder form, Red Lead soon turns black upon exposure to light. Darkening is due to the reduction of Red Lead to Lead Monoxide and dark brown Lead Peroxide: $\text{Pb}_3\text{O}_4 \rightarrow 2\text{PbO} + \text{PbO}_2$. This reaction is not produced by oxidation, it will occur in a vacuum tube exposed to light. When the pigment is ground in an oil or resin, this darkening does not take place.¹¹⁸

Red Lead is very poisonous, sensitive to Hydrogen

¹¹⁵Weber, ARTISTS' PIGMENTS, p. 105.

¹¹⁶Maerz and Paul, DICTIONARY OF COLOR, p. 19.

¹¹⁷Doerner, MATERIALS OF THE ARTIST, p. 74.

¹¹⁸Weber, ARTISTS' PIGMENTS, p. 105.

Sulphide, is attacked by hydrochloric acid, but is indifferent to alkalies. Red Lead should not discolor alcohol. If it does, it has been adulterated with a coal-tar dye. Like white lead, this color requires very little oil, 15%. When it is mixed with oil it is fairly permanent. When mixed in oil with White Lead, it fades. Red Lead can be used only as an oil color; as a powder or in a fresco, it eventually turns black.¹¹⁹

When Red Lead is ground in linseed oil, it hardens quickly and yields a quick-drying color. Owing to its exceptional covering and weather-resisting properties, it is used frequently as a heavy-paint for underpainting on metals and as a protection against rust.¹²⁰

When Red Lead is produced under insufficient heat, a red-yellow oxide forms, which is not permanent. This can be eliminated by washing with sugar-water.¹²¹

Dilute Nitric Acid decomposes this pigment to Lead Nitrate in solution and a dark brown Lead Peroxide. This reaction yielding the dark brown peroxide distinguishes Red Lead from pigments of a similar color, e.g. Vermilion, Chrome Red, and Cadmium Red.

Red Lead was known by the ancient Romans and Greeks

¹¹⁹Doerner, MATERIALS OF THE ARTIST, p. 74.

¹²⁰Weber, ARTISTS' PIGMENTS, p. 105.

¹²¹Doerner, MATERIALS OF THE ARTIST, p. 74.

as Minium, the Latin for Vermilion.¹²²

SIENNAS, NATURAL AND CALCINED

The term SIENNA is derived from the Italian town of Siena. The pigment was first used here as a color. It was then called "Terra di Siena"--earth of Siena--with a single 'n', the Italian spelling.¹²³

Raw Sienna is a natural variety of Ochre. It contains a large percentage of iron hydroxides in it besides silicic acid. It is principally obtained from Tuscany, the Harz mountains. It is transparent and has good color strength. It works well in oil¹²⁴ even though it requires up to 200% or more oil in its preparation as an oil.¹²⁵ Its properties are the same as the Ochres.

The synonyms for Raw Sienna are: Terre de Si-
enne, Terra di Siena, Tierra de Siena, and Rohe Sienna.¹²⁶

Raw Sienna is a cool, grayish brown.¹²⁷

Burnt Sienna is a calcined or burnt natural Raw Sienna. The iron hydrate, which is the yellow color giving principle of Raw Siennas, is converted by calcina-

¹²²Weber, ARTISTS' PIGMENTS, p. 105.

¹²³Fabri, COLOR, p. 103.

¹²⁴Weber, ARTISTS' PIGMENTS, p. 103.

¹²⁵Doerner, MATERIALS OF THE ARTIST, p. 69.

¹²⁶Weber, ARTISTS' PIGMENTS, p. 103.

¹²⁷Fabri, COLOR, p. 103.

tion into red iron oxide, Fe_2O_3 , changing the translucency and deepening the hue of the pigment. It is an inexpensive pigment and is not liable to be adulterated.

Hydrochloric acid dissolves the iron of ochres and siennas and forms a yellowish solution of iron chloride. The earthy and clay constituents remain as residue.¹²⁸

It is a fiery glazing color and requires a lot of oil, 180%, and as an oil is apt to jelly. This may be remedied by washing, but the sienna loses much of its fire.¹²⁹

The synonyms for Burnt Sienna are: Terre Sienna brulee, Terra di Siena bruciata, Tierra Siena tostada, and Gebrannte Sienna.¹³⁰

Burnt Sienna is a mahogany brown color and is good for warm shadows on the human figure.¹³¹

TERRE VERDE

Green Earth, Terre de Verone,

Veronese Green, Veronese Earth,

Terre verte, Tierra verde,

Gruenerde

¹²⁸Weber, ARTISTS' PIGMENTS, p. 27.

¹²⁹Doerner, MATERIALS OF THE ARTIST, p. 71.

¹³⁰Weber, ARTISTS' PIGMENTS, p. 27.

¹³¹Fabri, COLOR, p. 103.

As its name, GREEN EARTH, signifies, it is a substance that is found in nature, a clay colored with green hydrated oxide of iron. It is found all over the earth. The best variety is of a deep olive-green color, and is found at Monte Baldo, near Verona.

Terre Verde is a product of natural disintergration of certain minerals and is composed of silicates of iron and other elements. The iron silicate is the main coloring principal. The best varieties are selected, treated with dilute hydrochloric acid to remove any calcium carbonate (whiting) and ochres, and washed thoroughly. It is ready for use.

It is dependable in oil, is semi-opaque, and has weak tinting strength.¹³² It requires 100% oil but dries normally. It is not poisonous.

Terre Verde dissolves partially in hydrochloric acid and discolours to a yellowish-green hue. It does not dissolve in alkalies nor does it discolor in water, ammonia, or alcohol.¹³³ When calcined, it is converted into an ochre-brown color--Burnt Terre Verde. It is permanent and durable.

Terre Verde is imitated by the mixtures of Yellow Ochre and Prussian Blue. Alkalies destroy the Prussian Blue in such mixtures and turn the same brown color. Green Ultramarine is used as a substitute for Terre Verde.

¹³²Weber, ARTISTS' PIGMENTS, p. 110.

¹³³Doerner, MATERIALS OF THE ARTIST, p. 86.

It can be detected by the addition of hydrochloric acid. Hydrogen Sulphide is formed.¹³⁴

ULTRAMARINE BLUE

Lapis Lazuli Blue, Bleu d'Azur,
 Outremer, Oltremeare,
 Ultramar, Lasurstein, Ultramarine Ash,
 Cendre d'outremer, Cenere d'oltremare,
 Ceniza de ultramar

The stone Lapis Lazuli from which the genuine Ultramarine is obtained, was known to Romans and Grecians, as SAPHIR (SAPPHIRE) but mention of its use as a color source for the pigment, ultramarine, dates between the thirteenth and fourteenth centuries. The finest varieties of Lapis Lazuli are found in Tibet. It is also found in Siberia, Persia, and China. The natural Ultramarine is usually found to have gold-like specks consisting of Iron-Pyrites, FeS_2 (Fool's Gold) scattered through the mineral. The mineral is composed of silicon, aluminum, sodium, sulphur and oxygen. The molecular construction of the compound is not definitely known. It is most peculiar that such a strong color should be produced from a compound of elements which of themselves have no color (with the exception of sulphur).

¹³⁴Weber, ARTISTS' PIGMENTS, p. 110.

The method of extracting the blue color from the stone consists in selecting the purest pieces, which after having been finely ground, levigated, and washed, are kneaded together in the form of a dough with a little wax, rosin, and linseed oil added in a weak solution of potash or soda lye. The finest particles of color are withdrawn by alkaline water and settle out when left standing. The dough retains the foreign mineral substances.¹³⁵

The second and consecutive extracts from the same dough become more gray in color. The first extraction is of the purest and deepest blue color. The last extraction, a blue gray, contains a lot of foreign materials and is the least valuable. These last extractions are known as Ultramarine Ash.

Genuine Ultramarine is permanent to light, moisture, and is unaffected by hydrogen sulphide. It is more transparent than artificial ultramarines. When ultramarine is applied in heavy application (impasto) in oil, some varieties have a tendency to go blind or become gray in color with age. This is known as "Ultramarine sickness." This phenomenon is very rare and never occurs when white has been mixed with it. Weak and strong organic and mineral acids, except carbonic acid, readily decompose ultramarines and destroy the color with the

¹³⁵Ibid., p. 112.

evolution of Hydrogen Sulphide.¹³⁶ The color is not readily destroyed by heat. The addition of dyes to brighten the color is detected by shaking a sample of the pigment with water or alcohol, the ultramarine is insoluble and will settle to the bottom as a precipitate. Caustic alkalies will discolor them to a brownish hue if Prussian Blue is present. Ammonium hydroxide will produce a blue solution if copper blues are present. Gypsum, barium sulphate, chalk, china clay, magnesium, and carbonate are sometimes added to cheapen the product but reduce the tinting strength of the color.¹³⁷

UMBERS, NATURAL AND CALCINED

Umbers are varieties of ochres containing manganese oxide and iron hydroxide. The color because of its manganese content, is an excellent dryer.¹³⁸

The best kinds of Raw Umber is obtained from the island of Cyprus. It is durable, permanent, and adaptable to all techniques. It require 80% oil.

When Umbers are treated with warm hydrochloric acid, chlorine gas is evolved and is recognized by its characteristic disagreeable and piercing odor.¹³⁹

¹³⁶Ibid., p. 113.

¹³⁷Ibid., p. 114.

¹³⁸Doerner, MATERIALS OF THE ARTIST, p. 87.

¹³⁹Weber, ARTISTS' PIGMENTS, p. 104.

When Umbers are treated with alkalies, they discolor a little and when heated they become a reddish brown.¹⁴⁰

This brown red pigment is called Burnt Umber. Its color is obtained from large amounts of iron hydroxide and oxides of manganese. Through roasting there is a consequent loss of water, resulting in a conversion of iron hydroxide to iron oxide.

It is an inexpensive pigment, is permanent, semi-transparent, and has been in use since classical times.¹⁴¹

The synonyms for Raw Umber are: Cyprus Umber, Turkey Umber, Terre d'ombre, Terra d'ombra, Tierra de sombra, and Umbra.¹⁴²

The synonyms for Burnt Umber are: Terre d'ombre brulee, Terra d'ombra bruciata, Tierra de sombra tostada, and Gebrannte Umbra.¹⁴³

VERMILION

English Vermilion, French Vermilion,
Chinese Vermilion, Orange Vermilion,
Scarlet Vermilion, Cinnabar,

¹⁴⁰Doerner, MATERIALS OF THE ARTIST, p. 87.
¹⁴¹Weber, ARTISTS' PIGMENTS, p. 28.
¹⁴²Ibid., p. 104.
¹⁴³Ibid., p. 28.

Quicksilver Vermilion, Sinopis,
 Vermiglione, Vermellon,
 Zinnober

All hues are pure Mercuric Sulphide--HgS.

It is found in the mineral Cinnabar (a mercury blend) in Spain, China, Japan, Mexico, Peru, Germany, Austria and California. The Natural mineral is rarely pure enough to be used as a pigment. It is manufactured from the elements, mercury (quicksilver) and sulphur, by either the Dry Method or the Wet Method.

In the dry method, the raw materials used are in a dry condition.¹⁴⁴ Eighty-four parts by weight of mercury are mixed with sixteen parts by weight of sulphur, until an amorphorous black powder (Ethiop's Mineral) is formed. From this powder vermilion is obtained by sublimation. The Ethiop is pure mercuric sulphide and is unchanged chemically during the sublimation process. The color change is entirely due to the physical change that has taken place. It is then treated with hot alkaline solutions, in order to remove any free sulphur, washed, and are ready for use. Brighter and purer colors are obtained when the pigment is washed than when it is not. The resultant color will vary from dark red to light red hue. In Holland $2\frac{1}{2}\%$ of Red Lead or finely divided metallic lead is added to it.

¹⁴⁴Ibid., p. 117.

In 1687, G. Schulze published the first process for preparing Vermilion by the wet method.

In the wet method, the quicksilver and sulphur are ground together in the presence of water. After the black mixture is stirred for many hours with a warm solution of caustic potash or potassium sulphide, the pigment develops the desired vermilion color. It is then washed and dried.¹⁴⁵

Colors obtained from the dry method and the native product, show a greater stability under exposure to direct sunlight. Vermilion inclining towards a bluish tinge has a greater permanence than those of orange or scarlet hues. As an oil color, pure Vermilion, where properly protected by a film of oil and varnish is permanent if not exposed to direct sunlight. If overglazed with alizarin madder, Vermilion is very unlikely to undergo any change in color. It is opaque and is a scarlet color.

The pigment does not require much oil in its preparation; it is a slow drier and must be carefully ground to prevent the separation of the oil from the pigment. Impure air, sulphurous gases, and moisture have no affect on Vermilion. It is stable with other durable pigments. It will discolor when impure and when mixed with White Lead.

¹⁴⁵Ibid., p. 118.

Pure Vermilions are insoluble in water, alcohol, alkalies, and in dilute acids. Nitric acid does not react with Vermilion. The presence of Red Lead shows a brown discoloration. A solution of sodium sulphide, with the addition of sodium hydroxide will dissolve vermilion readily. Dyes can be detected with water, alkalies or alcohol; the liquid becomes colored. When vermilion is heated, a change takes place in the color. It changes from a bluish to a brown and eventually to a black hue. If it is still heated once it turns black in color, the mass will burn with a bluish flame and leave only a trace of ash. Sodium Sulphide will blacken vermilion.¹⁴⁶ A mixture of nitric and hydrochloric acids will dissolve vermilion to a colorless solution. The solution will be of mercuric chloride.¹⁴⁷

Vermilion was known of at least 2500 years ago. It was ground from the mineral mercuric sulphide, Cinnabar, and was sometimes referred to as Cinnabar Red.¹⁴⁸ It was used by the Egyptians in 400 B.C. It was used by the ancient Hebrews as early as 600 B.C. and was called "schaschar". It is thought to have been used by Assyrians and Chinese even earlier than this.¹⁴⁹

¹⁴⁶Ibid., p. 119.

¹⁴⁷Ibid., p. 120.

¹⁴⁸Maerz and Paul, DICTIONARY OF COLOR, p. 154.

¹⁴⁹Weber, ARTISTS' PIGMENTS, p. 120.

WHITE LEAD

Cremnitz White, Flake White, Lead White,
 Silver white, Dutch White Lead,
 Blanc d'Argent, Blanc de Plomb,
 Bianco di pilmobo, Blanco de plomo
 (albayalde),
 Bleiweiss, Cerussa Alba,
 Ceruse, Kremser Weiss,
 Blanco de Cremnitz

It is composed of Basic Lead Carbonate-- $2\text{PbCO}_3 \cdot \text{Pb(OH)}_2$.

White Lead was known to the ancients by the name of CERUSSE. It was prepared from lead and vinegar. After the fall of the Roman Empire, it was first prepared at Venice, later at Crems in Austria, then Holland, England, Germany and France. Today the United States is the largest producer.

White Lead is made by many different processes. In the Dutch Process, Carbon Dioxide, oxygen of the air, and water vapor (moisture) react on metallic lead in the presence of acetic acid fumes (vinegar). Reactions are brought about by stacking clay pots containing dilute acetic acid and flat metallic lead buttons, coils or buckles, in tiers and covering them with fermenting tan bark, spent tan or fermenting dung. Later during decomposition carbon dioxide and heat are evolved, thereby

evaporating the acetic acid and forming Lead Acetate (Sugar of Lead) on the surface of the lead. The Lead Acetate is converted into White Lead by the carbon dioxide. About ninety days are required for complete corrosion.¹⁵⁰

A test experiment can be performed on a small scale by pouring a little acid into a bowl and fastening a lead plate over the top in such a way as not to touch the acid. Very soon a thin white coating is formed on the lead. This coating is White Lead. If acid comes into direct contact with the lead, colorless crystals are formed. If these crystals are in small quantities, they are not harmful to the pigment. But if they are present in larger quantities, White Lead turns brown and effloresces. This can be eliminated by washing.¹⁵¹

In the Quick Process, heated vapors of dilute acetic acid and carbon dioxide act upon atomized metallic lead, is blown with steam into a large revolving wooden cylinders, and produces White Lead which is more amorphous in character and less crystalline in structure than the White Lead produced by the Dutch Process.

In the Mild Process, finely divided metallic lead powder is mixed with air and water and form basic hydroxide of lead which is acted upon by the carbon dioxide gas to produce White Lead. In this process no acids, alkalis

¹⁵⁰Ibid., p. 121.

¹⁵¹Doerner, MATERIALS OF THE ARTIST, p. 51.

or chemicals are needed.¹⁵²

A good variety of White Lead should be composed of 70% carbonate of lead and 30% of lead hydroxide. Varying percentages of lead carbonate and hydroxide affect opacity, consistency and durability.

White Lead is one of the most opaque white pigments and is equaled only by Permalba. It is sensitive to hydrogen sulphide and forms black lead sulphide. As an oil it becomes yellowish in color upon aging and less opaque. When it is exposed to the elements, White Lead becomes chalky after long exposure. It is permanent, especially so when protected by a coat of oil or varnish.¹⁵³

Its solubility in sodium chloride causes disintegration of the pigment when it is exposed to sea air. Carbon Dioxide in the air attacks White Lead.¹⁵⁴

White Lead is very poisonous. Even the inhaling of the dust containing it can cause serious consequences. When grinding White Lead with a medium, the greatest caution is advisable, and the hands should be very carefully washed. This danger should not be underestimated.¹⁵⁵

When heated, White Lead loses carbon dioxide and water and is slowly converted into lead oxide--PbO, (Litharge, a yellowish-red color). Massicot is a modification

¹⁵²Weber, ARTISTS' PIGMENTS, p. 121.

¹⁵³Ibid., p. 122.

¹⁵⁴Ibid., p. 123.

¹⁵⁵Doerner, MATERIALS OF THE ARTIST, p. 53.

of lead oxide, a pale yellow color, which is obtained in the same manner. By prolonged heating lead oxide thus formed combines with additional oxygen and forms the bright red oxide known as Minium-- Pb_3O_4 . When heated with carbon, White Lead becomes yellow in color and upon further heating it is converted into metallic lead.

White Lead is insoluble in water and any sugar of lead if present is brought into solution and the detection of which may be made by adding sodium sulphide (formation of black lead sulphide in the presence of lead in solution) or by sulphuric acid (formation of insoluble white lead sulphate).

Hydrochloric acid precipitates insoluble lead chloride from solutions of White Lead and is soluble in boiling water. Sodium carbonate precipitates lead carbonate from solutions of White Lead. Caustic soda dissolves White Lead.

Upon the addition of potassium bichromate to a neutral solution of White Lead, a yellow precipitate of insoluble Chrome Yellow (Lead Chromate) is formed.

White Lead which has become discolored is bleached (oxidized) to white lead sulphate when it is treated with Hydrogen Peroxide-- H_2O_2 .

A cheap substitute for White Lead is Basic Lead Chloride-- $\text{PbCl}_2\text{Pb}(\text{OH})_2$ --, but it is not durable in mixtures. It can be detected by its solubility in hot dilute nitric

acid without effervescence.¹⁵⁶ The addition of a drop of silver nitrate forms a white flocculent precipitate.¹⁵⁷

ZINC WHITE

Zinc Oxide, Chinese White, French Zinc,

Blanc de Zinc, Snow White,

Bianco de Zinco, Blanco de Zinc,

Zinkweiss

Zinc White is composed of Zinc Oxide-- ZnO .¹⁵⁸

Not until early in the eighteenth century was there sufficient interest manifested in metal to endeavor to produce it from ore. A tradition recorded by Berkman says that an Englishman visited China to learn the art of making Zinc. He attained his knowledge, returned with the secret and soon afterwards erected a Zinc plant at Bristol, England for the production of Spelter. This plant was erected in 1743. Shortly after the establishment of this Spelter plant at Bristol, the product, Spelter, was used to coat iron sheets to prevent them from rusting. This was the beginning of Galvanized Iron. An operator of this process noticed that a fine white powder collected about the edges of his melted zinc bath. This proved to be Zinc Oxide.

¹⁵⁶Weber, ARTISTS' PIGMENTS, p. 124.
¹⁵⁷Ibid., p. 125.
¹⁵⁸Ibid., p. 128.

The commercial production of Zinc Oxide as a pigment was started in France in the latter part of the eighteenth century by Leclair and Sorel. Leclair was a paint grinder and master painter. He made elaborate and conclusive tests with Zinc Oxide. Investigations of Leclairs' claims that he had found a pigment that produces a whiter and more desirable paint, by the French Government, led them to specify Zinc Oxide to be used in all Government work. Later White Lead was prohibited above certain percentages and Zinc Oxide was specified in its place.

It was made by burning spelter with an excess amount of air.¹⁵⁹ It is now made by the French Process. The zinc ores are smelted, the zinc being distilled off and collected as molten zinc. The metallic zinc is cast in slags which are again melted in different kinds of furnaces and the melted zinc upon further heating vaporizes. The fumes upon meeting the air burn with a bright greenish-yellow flame to produce Zinc Oxide. After it is cooled and blown through large pipes, it is collected. It is sampled, graded, and packed ready for use.¹⁶⁰

Zinc White was first introduced as an artist's color in 1840. As compared with Cremnitz White, it is much looser, bulkier powder. It is colder in appearance and covers well. Zinc White is very economical to use and is practically non-poisonous. For this reason it is

¹⁵⁹Ibid., p. 129.
¹⁶⁰Ibid., p. 130.

preferred to White Lead in grounds. Zinc White is permanent to light, does not yellow, and as a basic mineral color has less than White Lead a solidifying effect upon fatty oils. Hydrogen Sulphide acts upon Zinc White and produces a white Zinc Sulphide.¹⁶¹

When exposed to the air, Zinc White becomes gritty and through the absorption of carbonic acid turns into basic Zinc Carbonate. It should therefore be kept in tightly closed glass jars. When heated, it will again turn to powder.

If Zinc White is heated, it turns lemon yellow and in cooling white. It differs in this respect from White Lead. Pure Zinc White dissolves in alkaline solutions, ammonia, and acids, in the latter without effervescence. Effervescence indicates chalk and an odor of hydrogen sulphide is present. Lithopene, clay, and blanc fixe remain as residues. Acetic acid attacks Zinc White. Zinc White disintegrates quickly out of doors, and it increases in volume and causes cracks. Ground in oil, Zinc White dries slowly, especially so if it is ground in poppy oil. This retarded drying is welcomed by many painters, but the color never dries as solidly as White Lead. Zinc White is not suited to underpainting in oil for cracking will follow.

Formerly Zinc White possessed more glazing qualities, but today it is used by artists for opaque paint-

¹⁶¹Doerner, MATERIALS OF THE ARTIST, p. 55.

ing because it does not turn yellow in oils as does White Lead.¹⁶² Zinc White is so transparent and so weak in covering power that you need a great deal of it to make a color lighter.¹⁶³

¹⁶²Ibid., p. 56.

¹⁶³Fabri, COLOR, p. 105.

INDEX

- Alizarin Lakes, 18, 19, 20,
21.
Antwerp Blue, 21.
Asphalt, 7.
Aureolin, 21, 22.
Azure, 22, 23.
Barium Yellow, 23, 24.
Blue-Black, 24, 25.
Blue-Green and Green-Blue
Oxide, 25, 26.
Brilliant Yellow, 26.
Cadmium Yellow, 3, 26, 27,
28, 29.
Cadmium Red, 29, 30.
Carbon Black, 30, 31.
Cerulean Blue, 31, 32.
Chrome Green, 32, 33.
Chrome Red, 33, 34.
Chrome Yellow, 34, 35, 36,
37.
Cobalt Blue, 37, 38.
Cobalt Green, 38, 39.
Cobalt Violet, 39, 40.
Cyaneous, 40, 41.
Delft Blue, 41.
Emerald Green, 3, 42, 43.
How Colors Made, 5, 6, 7,
8.
Indian Red and Red Iron
Oxides, 43, 44, 45.
Indian Yellow, 3, 4, 45,
46, 47.
Lamp Black, 47, 48.
List of Colors, 14, 15, 16.
Malachite Green, 48, 49.
Manganese Violet, 3, 49,
50, 51.
Mars Colors, 4, 51, 52.
Methods to Test Pigments,
8, 9, 10, 11, 12, 13,
14.
Naples Yellow, 3, 52, 53.
Ochres, Natural and Calcined,
53, 54, 55, 56, 57.
Oxide of Chromium, Opaque,
57, 58.

Oxide of Chromium, Trans-
parent, 3, 58, 59.

Permalba, 59, 60.

Prussian Blue, 60, 61, 62,
63.

Red Lead, 64, 65, 66.

Siennas, Natural and Cal-
cined, 2, 66, 67.

Sources of Pigments, 1, 2,
3, 4, 5.

Standardization of Color
Names, 16, 17.

Strontium Yellow, 3.

Terre Verde, 67, 68, 69.

Titanium White, 3.

Ultramarine Blue, 69, 70, 71.

Umbers, Natural and Cal-
cined, 71, 72.

Vermilion, 3, 72, 73, 74,
75.

White Lead, 3, 76, 77, 78,
79, 80.

Zinc White, 3, 80, 81, 82, 83.

BIBLIOGRAPHY

The books in the following list were the main literary sources used in studying artists' pigments. Many were used in tracing the exact meanings of obscure color names and in clearing up errors in regard to synonymous terms. Many other books were also referred to, but as they were found merely to duplicate material already well authenticated, they were excluded from this list. The listing of these books would serve no purpose but to pad the list. Other books were used in determining the first literary appearance of color names.

Cennini, Cennino D'Andrea. IL LIBRO DELL' ARTE (THE CRAFTSMAN'S HANDBOOK). Translated by Daniel V. Thompson, Jr. New York: Dover Publications, Inc. 1933.

Doerner, Max. THE MATERIALS OF THE ARTIST AND THEIR USE IN PAINTING WITH NOTES ON THE TECHNIQUE OF THE OLD MASTERS. Translated by Eugen Neuhaus, Ph.D.h.c. New York: Harcourt, Brace and Company. 1934.

Fabri, Ralph. COLOR, A COMPLETE GUIDE FOR ARTISTS. New York: Watson-Guptill Publications. 1967.

Maerz, Aloys John, and Paul, M. Rea. A DICTIONARY OF COLOR. New York: McGraw-Hill Book Company. 1930.

Plane, Robert A., and Sienko, Michell J. CHEMISTRY. New York: McGraw-Hill Book Company. 1966. Third Edition.

Weber, F. W. ARTISTS' PIGMENTS: THEIR CHEMICAL AND
PHYSICAL PROPERTIES. New York: D. Van Nos-
trand Company. 1923.