# Materials for Permanent Painting

Maximilian Toch

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A MANUAL FOR
MANUFACTURERS, ART DEALERS, ARTISTS
AND COLLECTORS

*By Maximilian Toch*

Member American Institute Chemical Engineers
Municipal Lecturer on Paints, Colors, Etc., College of the
City of New York
Past President of the Chemists' Club
Past Chairman Society Chemical Industry, N. Y. Section
Director of [illegible]
Author of [illegible]
Fellow of the Chemical Society of London
Etc., Etc.

NEW YORK
D. VAN NOSTRAND COMPANY

*Gesso Tempera Painting on wood, probable age 600 years.*

*(Painting in the possession of the author.)*

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NEW YORK
D. VAN NOSTRAND COMPANY
1911

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The Eddy Press Corporation
Cumberland, Md.

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# Preface

## PREFACE

IN the course of my acquaintance with artistic painters, I was astonished to find the enormous amount of ignorance that exists among them as to the composition of the materials which they use and the science of painting. Almost every painter of note will tell you what a great pity it is that the science of making colors is lost, and that the ancient painters and great masters were so successful primarily because their pigments and materials were far superior to those which we can obtain to-day. This statement is so diametrically opposed to the facts that I have been prompted to make a study of paint pigments in order to throw some light on this subject, and demonstrate to the painter that the colors of to-day are far superior to the colors used by the ancients, and show that the principal fault lies with the manufacturer, who makes fugitive colors, for the use of which there is no scientific nor commercial reason. Almost any large dealer in artists' colors has upwards of 200 pigments on sale. In the first place, no palette could hold any such quantity, and in the second place, there are possibly only 10 or 15 sufficiently permanent pigments to warrant their use.

The correct, complete and most edifying book on this subject has never been written, nor is my effort of much value, excepting perhaps from the standpoint of the chemist. Some day there will be born a man, who will be both a color chemist and a painter, and that man will write the ideal book on the subject. The popular impression is that all chemists must have a comprehensive knowledge of the chemistry of pigments, but this is not true, as there are very few chemists who know anything about the technology of paints, because it is a specialty which very few have worked up, and no matter how proficient a chemist may be, if he is not an artistic painter, he cannot advise how a sky should be painted, or what particular greens to use for foliage and shadows. The technique of the fine arts is a subject by itself, and while I may be supposed to have some knowledge on this subject, I frankly admit my inability to paint, but inasmuch as I feel very certain of one part of my subject, that is the physical and chemical properties of the pigments, I do not hesitate to recommend in plain language exactly what the painter shall do with reference to his colors, and the materials upon which he paints.

Furthermore, I was very much astonished to find that in the art schools of the various countries no attention whatever is paid to the chemistry of colors. A painter should be aware that certain pigments are affected by the fumes arising from vegetables in a dining room, and that these fumes form chemical compounds with certain pigments, and a painter should likewise know that the atmosphere of large cities is contaminated with acid gases which are absent in smaller places, and which did not exist before the age of the burning of coal as fuel.

I trust, therefore, that my work will be taken seriously, and that the poorer painter will recognize that he need not use expensive colors to produce permanent results. I am glad that I am not actuated by any commercial motive in writing this book, for, although I have been a color manufacturer for many years, I have never made, nor have I the intention of making tube colors for artists' use, but I have made quantities of finely ground colors for many of my friends, who are painters, and have demonstrated to them that sometimes the ordinary paints ground in oil, such as are used by house decorators, are sufficiently good for many purposes, and in many instances produce the same results as the more expensive colors filled in tubes. I have tried to write as fully as I know and give as plainly as I could the description relating to the more expensive colors, condemning those which should be condemned, and recommending others as long as there is nothing superior to be had.

It may interest the reader to know why I take such a positive stand with reference to the fading, drying and other physical characteristics of colors, in view of the fact that the majority of investigators vacillate continually.

# Preface

In 1886, while I was still a chemical student, I made my first investigation of tube colors, and from that day to this I have been interested in the subject of the manufacture of paints and pigments as a vocation, and have always been interested in the subject of the application of artistic pigments as an avocation. Drying tests can, of course, be conducted in a few weeks, but extensive tests take years, and although it is reasonable to determine the permanency of a color by exposure to the bright sunshine for three months, I have made experiments along these lines which have involved exposure for over five years.

When pigments are mixed with an aqueous medium containing a little gum, and the resulting picture is hermetically sealed, no decomposition takes place, because the majority of chemical reactions cease in the absence of moisture, but linseed oil or varnish medium will generate moisture and certain gases, producing a slow decomposition, so that it often takes years to make a determination of which a description can be written in a few minutes.

It is a great pleasure for me to acknowledge the assistance I received from Dr. George F. Kunz, who gave me a fairly complete collection of semi-precious minerals, all of which represented the pigments used by the ancients and with which I conducted many of my experiments.

# CHAPTER I

## THE HISTORY OF PAINTING

THE decorative art of using colors is probably as old as man. We have the instinctive effort of the barbarian, who bedecked his body with colored earths, and we have the frescoes and wall decorations and the painting of the columns in the temples of Luxor and Karnak, as evidence of the use of pigments for decorative purposes. There seems to be little doubt that from the earliest day of decorative painting down to the fourteenth century, the media used consisted of some albuminous or gelatinous compound mixed with water. The white of egg or the entire egg mixed with lime was evidently the principal medium used to fasten colors, although many other substances were used, such as the liquid obtained by boiling parchment and the skins of animals in water, which is practically the same thing as using glue.

In the method of painting with the white of egg which has always been known as tempera, the paint was generally applied to a ground of gesso, which is the Italian word for gypsum, or plaster of Paris, and the pigments which were used, and the methods of preparation of the wood foundations for painting were so perfect that absolutely no decomposition takes place in gesso tempera painting, for we have brilliant examples that are over 600 years old practically in their pristine condition. Pliny mentions the use of milk as a medium, and while it is doubtful whether we have any authentic samples of early paintings with milk, we have the custom still in vogue, for there are thousands of tons of kalsomine or water colors made at the present day in which the binding material is casein, which is the gluey substance that is contained in milk. In addition to these media the early monks used almost every conceivable substance of a sticky nature, such as wax, honey, wine boiled until it is slightly thickened (glucose or sugar), the juice of various plants, and from the eighth century on we begin to have evidence of the use of drying oils in the form of some nut oil (more than likely linseed oil mixed with a varnish), for in Italy before the days of oil, we have, according to Cennini, the mention of vernice, from which evidently our word "varnish" has been etymologically derived.

Oils were known to the ancients as an article of food and as a material for anointing the body, sufficient evidence for this being found in the Bible, and as many priests busied themselves with painting and used the materials at hand, there is no doubt that many of them used cooking oils such as olive, flax and nut oil in many of their works. Eastlake, in his most valuable book,* makes the statement that Aetius, a medical writer of the fifth and the beginning of the sixth century, mentions at great length, a drying oil in connection with works of art, and it was this early writer who described at full length what we probably recognize as "linseed oil," and after mentioning this, he makes the statement, "walnut oil is prepared like that of almonds, either by pounding or pressing the nuts, or by throwing them into boiling water after they have been bruised. It has a use besides a medicinal use, being applied by gilders or encaustic painters, for it dries, and preserves gildings and encaustic paints for a long time."

The popular statement that the brothers Hubert and Jan Van Eyck were the first to paint permanent pictures in oil, is only true in so far that both of these men evidently investigated all the work that had been previously done, as the Italian historian, Facius, speaks of Van Eyck as having consulted the previous authorities with much profit. † Facius, whose full name was Bartolommeo Facio, appears to have first published his work in 1456, but we have ample evidence as far back as Henry III, in 1239, showing that oil painting was practiced in England as a trade. In view of the fact that the work by Sir Charles Eastlake is to be found in few libraries, and that his celebrated book is therefore not easily accessible, I quote from his in-

* Materials for a History of Oil Painting.

† Eastlake's Material for the History of Oil Painting, p. 25.

vestigations as follows: "In 1239 (23d of Henry III) oil is mentioned in connexion with painting. Similar notices appear in numerous account-rolls belonging to the reign of Edward I, viz., from 1274 to 1295; and in others dated 1307, the 1st of Edward II."

Another series exists in the records of Ely Cathedral, the dates extending from 1325 to 1351. A great number of the same kind are preserved in accounts belonging to the reign of Edward III, and relating to the decoration of St. Stephen's Chapel, from 1352 to 1358. Partial translations (unfortunately without the original text) of some of the last-mentioned records have been published in "Smith's Antiquities of Westminster."* The extracts made by that writer relate to glass-painting, architecture, and decorations generally. Of certain weekly accounts (belonging to the reign of Edward I), amounting originally to one hundred and forty-two in number, he states that he had found eleven only.† In the course of a recent investigation forty-four have been discovered. However interesting in other points of view, these numerous documents throw but little light on the practice of oil painting. The same materials constantly reappear, but there is no direct allusion to their use, except as regards the process of varnishing. Such passages as the following refer to the commonest operations of this kind: "To the same (Stephen Le

* London, 1837. † Ib., p. 76.

Joigneur) for varnishing two coffers, 8d.";* and else, "To Richard de Assheby for preparing with white, covering with ochre, and varnishing the King's Chamber, according to contract. 32 shillings." † A few specimens of the mandates and accounts above adverted to, beginning with those of the thirteenth century, will therefore suffice. The first in order of time is familiar to many, having been originally published by Walpole.

1239. "The King to his treasurer and chamberlains. Pay from our treasury to Odo the goldsmith and Edward his son one hundred and seventeen shillings and ten-pence for oil, varnish, and colours bought, and for pictures executed in the Queen's Chamber at Westminster, from the octaves of the Holy Trinity (May 25th) in the 23rd year of our reign, to the feast of St. Barnabas (June 11th) in the same year, namely, for fifteen days." ‡

It is here necessary to remark, in anticipation of the inquiry respecting varnishes, that the word vernix or vernisium, in the earlier notices of painting, does not mean a fluid composition, but dry sandarac resin, which, when melted and boiled with oil, formed a

* "Eidem (Stephanno le Joignur) pro vernicione ii. coffro rum Viii. d."

† "Richardo de Assheby pro bealbacions ocriacione et ver nacione camere Regis ad tascham xxxii. s."

‡ "Rex thesauriario et camerariis suis salutem. Liberate de thesauro nostro Odoni aurifabro et Edwardo filio suo centum et septemdecem solidos et decem denarios pro oleo, vernici, et coloribus emptis, et picturis factis in camera reginae nostrae apud Westm. ab octavis Sanctae Trinitatis anno regni nostri xxiii. usque ad festum Sancti Barnabe apostoli, eodem anno, scilicet per xv. dies."

varnish, in the modern sense of the term. The proofs of this will be given hereafter. It may be sufficient here to observe, that, in the English accounts, the quantity of varnish is always noted by weight, and that of oil by measure. The above passage should be translated "for oil, sandarac resin, and colours." It will be seen, that the order relates to the work of fifteen days only; but it does not follow that the oil varnish was used upon pictures, or operations in painting, then executed. In the portion of time specified some works may have been varnished and others prepared for it. The date of this mandate is a year before the birth of Cimabue.

In 1259, Master William, the painter, with his assistants, received forty-three shillings and ten-pence for painting a Jesse (no doubt the usual genealogical tree of Christ) on the mantel-piece of the King's Chamber (The Painted Chamber), and "for renovating and washing the paintings on the walls of the said chamber." *

This supposes that these celebrated works, consisting chiefly of subjects from the Old Testament and from the Apocrypha, were varnished. Size paintings, without such a protection, would hardly have been proof against this "ablution." The tempera, composed chiefly of yolk of egg, is firmer than size, and becomes very solid in time; but the colored remains of the

* "Magistro Willelmo Pictori cum hominibus suis circa Jesse in Mantell, camini Regis depingendum et circa picturam parietum ipsius camere Regis innovandam et abluendam, xliii. s. x. d."

Painted Chamber (the varnish probably having become decomposed from damp during the lapse of ages) easily yielded to the sponge when they were examined in 1819. *

In the period from 1274 to 1277 (3rd to 5th of Edward I), an account, apparently relating to the Painted Chamber, contains the following items: "To Reymund, for seventeen ℔. of white lead, ii. s. x. d. To the same, for sixteen gallons (?) of oil, xvi. s. To the same, for twenty-four ℔. of varnish, xii. s. To Hugo le Vespunt, for eighteen gallons of oil, xxxi. s.," etc. † Again: "To Reymund, for a hundred (Leaves) of gold, iii. s. To the same, for twenty-two ℔. of varnish, xi. s. i. d." ‡ Elsewhere: "To Robert King, for one cartload of charcoal for drying the painting in the King's Chamber, iii. s. viii. d." §

The last entry appears to relate to the drying of surfaces painted in oil, but the precaution may also have been necessary before varnishing tempera. The application of heat, even before painting in oil, according to the directions of Eraclius, will here be remembered: "Ad solem vel ad ignem siccare permittes." It can hardly escape observation, that the practice of oil painting taught by Eraclius agrees in many details

* See Gage Rokewode's Account of the Painted Chamber, 1842, p. 15.

† "Reymundo pro xviii. li. albi plumbi ii. s. x. d. Eidem pro xvi. gal. olei xvi. s. Eidem pro xxiiii. li. verniz xll. s. Hugoni le Vespunt pro xviii. gal. olei xxi. s."

‡ "Reymundo pro C. auri iii. s. Eidem pro xxii. li. verniz xi. s. i. d."

§ "Roberto King pro i. carecta carbonis ad picturam in Camera Regis desiccandam iii. s. viii. d."

with that exemplified in the English records; and the circumstance may warrant a supposition that he composed his treatise in this country. 1289 (17th of Edward I). The following materials are enumerated in an account relating to repairs in the Painted Chamber: "white lead, varnish, green, oil, red lead, tin-foil, size, gold leaf, silver leaf, red ochre, vermilion, indigo, azure, earthen vessels, cloth, etc." *

In 1292, oil and varnish are twice mentioned in a similar account. † In 1307, in consequence of a fire (which occurred in 1298), repairs were again undertaken, and similar materials were used.

The records of Ely are more conclusive as to the mixture of oil with the colors; and, as the materials are nearly the same as in the above extracts, it may be inferred that oil painting of some kind was employed at Westminster. Of this, indeed, there are other proofs.

1325. Among the items of an account, three flagons and a half of oil are mentioned "for painting

* "In albo plumbo, vernicio, viridi, oleo, plumbo rubeo, stangno albo, cole (Fr. colle), auro, argento, sinople, vermilone, ynde, asura, ollis, panno et allis minutis emptis ad viridandam novam Camereram de petra et ad emendaciones picture mangne Camere Regis sicut patet per particulas. Summa xii. li. vl. s. vi. d. ob." This extract is given in the work last quoted, but with some inaccuracies; for example, ranno for panno, and in the heading, verniorum for verinorum. There is no punctuation in the original account-rolls, but vernicio viridi should not have been connected. It would be unjust to point out these trifling oversights in an important and interesting work, without, at the same time, paying a tribute of respect to the memory of one who so often distinguished himself as an accurate and intelligent investigator.

† Item in iii. quarteronis olei empti. Summa ix. d. In l. lb. vernicio (sic) empt. Summa iiii. d. In ocra, plastro, filo et pelli emptis," etc.

the figures upon the columns."* The term "ymagines," in these and other English records of the time, is used indiscriminately for painted figures and for statues. In the treatise of St. Audemar the latter are distinguished as "ymagines rotunde." There can be little doubt that, in the above passage, painted figures were meant; and, in any case, oil colors were used.

In 1336, in a similar account, oil appears in abundance, forty-eight flagons altogether; and this may explain its absence in other entries, where colors and other materials are mentioned without oil. It should also be observed that, if, in mutilated documents, "varnish" appears alone, it may always be inferred that the oil (without which the vernix, or sandarac, was of no use) was originally included in the list of materials. In the last mentioned account columns were to be painted. †

In 1339 and 1341 oil again appears; in the account of the former date "for tempering the colours." ‡

In 1351 oil is mentioned "for making the painting in the chapel." § In all these documents, when varnish

* "In iii. lagenis et dimid. olei pro ymaginibus super columnas depingend. iii. s. vi. d."

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† "Item in vii. iv. albi plumbi emp. de eodem xii. s. prec. i. d. In xiii. lagenis olei wmpt. de Thoma d'Elm x. s. iii. d. ob. prec. lagen. x. d. ob. In vi. lagenis olei empt. de Thoma de Chayk iv. s. xi. d. prec. lagen. x. d. In xxviii. lagenis et dimid. olei empt. de Nich. de Wickam xxvi. s. i. d. ob. prec. lagen. xi. d. In dimid. lagen. olei empt. v/d. In vas terren, pro oleo imponendo iv. d. quad. In i. longa corda empt. pro le chapital deaurand. et column, depingend. viii. d.," etc.

‡ "In xxxi. lagenis et dimid. olei empt. de quodam nomine de Wickham pro coloribus temperandis xxl. s. prec. lagen. viii. d.," etc.

§ "In oleo empt. pro pictura facienda in capella x. s.," etc. The above extracts relating to Ely Cathedral will be found in the Archaeologia, vol. ix.

is included in the items, the quantity, as usual, is noted in weight.

The last accounts in the general list before given (1352-1358) relate to St. Stephen's Chapel. They are very numerous; but, as already observed, they afford no additional light respecting the particular applications of oil painting. In other respects they are of great interest; and, like those of the time of Edward I, indicate a practice in art corresponding in almost every particular with that described by Cennini.

The large supplies of oil which appear in the Westminster and Ely records, indicate the coarseness of the operations for which oil was required. The quantity supplied to Giorgio d' Aquila, at Pinarolo, has excited the surprise of Italian antiquaries; * but it now appears that contemporary examples, quite as remarkable, are to be found in English documents. Such notices as the following (not the only entries of the kind) at least remove all doubt as to the nature of the oil sometimes used, and the general purposes for which it was provided.

The extracts relate to St. Stephen's Chapel. Sept. 19, 1352, (25th of Edward III): "For nineteen flagons of painters' oil, bought for the painting of the chapel, at 3s. 4d. the flagon, 43s. 4d." † March 19, 1353:

* See a letter from the Padre Guglielmo Della Valle, in the Giornale di pisa, 1794. He endeavors to show, notwithstanding the plain expression, "non erat sufficiens in pingendo," that the oil may have been used for lamps.

† "Die Lune xix. Septembris. In xix. lagenis olei pictorum emptis pro pictura capelle precium lagene iii. s. iiii. d. xliii. s. iiii. d."

"To Thomas Drayton, for eight flagons of painters' oil, bought for the painting of the chapel, at 2s. 6d. the flagon, 20s." * May 13, in the same year: "To John de Hennay, for seventy flagons and a half of painters' oil, bought for the painting of the same chapel, at 20d. the flagon, 117s. 6d." † Contracting with this lavish use of oil, we find such entries as the following: "To Gilbert Pokerig, for two flagons of size, bought for the painting of the said chapel, 2d. To the same, for two earthen vessels for heating the size, three halfpence." ‡

Eggs, which afforded the vehicle for the finer work in tempera, are not mentioned: this may, however, be accounted for either by the incompleteness of the records of this period, or by the nature of the work, as the item occurs in earlier documents, hereafter to be noticed, belonging to the reign of Edward I (1274). It will be observed that the price of the oil used in St. Stephen's Chapel varies, and that sometimes it is more than three times the price of that employed at Ely about the same time. The expression "painters Oil," applied to the former, may explain this. It had been probably purified and deprived of its mucilage by exposure to the sun, in the mode then generally

* "Die Lune xix. die Marcii. Thome Drayton pro viii. lagenis olei pictorum emptis pro pictura capelle precium lagene ii. s. vi. d. xx. s."

† "Die Lune xiii. die Maii. Johanni de Hennaij pro ixx. lagenis et di. olei pictorum emptis pro pictura ejusdem capelle precium lagene xx. d. cxvii. s. vi. d."

‡ "Die Lune xix. die Marcii (1353). Gilberto Pokerig pro ii. lagenis de cole emptis pro pictura dicte capelle ii. d. Eidem pro ii. ollis terreis emptis pro cole calefaciendo i. d. ob."

practiced for the preparation of linseed oil which was to serve for better kinds of painting (on surfaces where it was desirable to produce a gloss), and for the composition of varnishes. This appears the more likely, as the oil was sometimes purchased of the (then) principal painter, Hugh of St. Albans. *

Cennino Cennini gives the most exact formulas for the preparation of drying oil and varnishes, including prescribed methods for the grinding of colors in oil for painting in oil on iron and on stone, and one of the most noteworthy facts that we have in conjunction with this remarkable Italian investigator is, the fact, that the description of the varnish kettles for the melting of the gum, and the implements used for stirring are almost identical in shape with those that are used in the present day, and in his description of the preparation of drying oil which we now popularly term "gold size," is a slow-drying linseed oil that remains "tacky" for several days, and dries without shrivelling. It is also noteworthy of mention that our methods for making an oil size do not differ to-day from the formulas prescribed by Cennini.

The early Italians were better book-binders than they were painters, and as nearly all of their subjects were of a religious nature, the madonnas with the gold-

* "Die Lune xxv. die Julii (1352) Eidem (Magistro Hugoni de Sancto Albano) pro xiii. lagenis olei pictorum emptis pro pictura diste capelle precium lagene iii. s. iiii. d. xliii. s. iiii. d." The same quantity, at the same comparatively high price, is entered on the 19th of September following. This extract has been already given.

en background, the saints with the golden halos, were all so wonderfully prepared, that to this day we have excellent examples of this art, which is really a mixture of book-binding and painting.

About the year 1400, the practice of oil painting had become thoroughly established, due undoubtedly, to the research and investigation of the Van Eycks. The examples of their oil painting which are in existence to this day are in a condition that is absolutely remarkable. Even a superficial examination of one of the paintings of Hubert Van Eyck in the National Art Gallery in London, shows a brilliancy and freshness that pays an inexpressible tribute to the wonderful care exercised by this master and his brother.

## CHAPTER II

## THE PIGMENTS USED BY THE ANCIENTS

THE permanence of the old paintings is entirely due to the fact that the painters had very few pigments to work with, and practically all of them were native earths which were in many instances exceedingly brilliant. The lapis lazuli which is the same thing as our ultramarine blue of to-day occurs in nature, and varies in shade from a greenish sky blue to a dark ultramarine. The selection of various shades of this most permanent pigment gave to all the painters who used it a blue which has not been surpassed.

For the yellow pigments there were ample yellow earths in the form of ochre and sienna, which while not very brilliant were sufficiently bright for all purposes.

The white effect about the gesso paintings was produced by whiting and gypsum, and as white lead was known 400 B. C., either as an artificial product or as a mineral known as cerusite which is a native carbonate of lead, the use of this pigment was well known and largely practiced, although its defects were noted by nearly every one of the early writers.

As far as green is concerned, there were several varieties of minerals that furnished green, principally malachite, which is a form of carbonate of copper, and no doubt when properly glazed was found to be amply permanent, although sulphur gases affected it.

In addition to these pigments they had Grecian green or Graecum which the French later on called verte de grece, from which the term verdigris is derived. Whether this was metallic copper subjected to vinegar as we now know it, or whether it was the turquoise mineral or clayey earth stained with phosphate of copper, as may have been the case, it is difficult to say, for the verdigris that we know in modern art is transparent, and has the qualities of a lake or stain, and not the qualities of a paint.

Concerning the reds which the ancients used, we know that they were familiar with all the red oxides of iron, and the Italians used not only calcined sienna which is a brownish red and now recognized as burnt sienna, but they also calcined ochre, which made a yellower red. The bright red or vermilion used from the thirteenth century on under the name of sinopia, deserves a chapter for itself, and will be described later on.

As regards the blue colors, indigo was used by the Phoenicians. This is an organic compound which at that time, according to the latest researches on the subject, was obtained from the extract of a certain fish. We now recognize this substance as Indican, which is chemically analogous to indigo, and is found as a product of decomposition, even in the human being. The dark blue dye that was used in Egypt, and is still preserved in some of the mummy cases is recognized as this particular indigo, and as the color is mentioned by Cennini, there is ample evidence of its use. It never was permanent, however, and all our philosophies on the colors of the ancients can only refer to those which have stood the test of time.

Concerning the blacks, we have evidence that russ which is equivalent to our lampblack was manufactured as far back as 1352, and that in the fourteenth century the calcining of paints even to the ancients was a familiar operation. *

There are about 215 tube colors for sale to-day for the use of painters, and out of this entire amount there are not over twelve that may have any possible use, and ninety-nine painters out of a hundred could get along almost perfectly with seven or eight pigments. The remainder of this vast number of pigments in existence are not only useless, but are a positive detriment, because every one of them has some inherent defect which makes it a menace to the permanence of paintings. Inasmuch as we are concerned with painting only as it has been tried since the time of Van Eyck, and as a large number of the paintings are still extant in a perfect state of preservation which

* See Eastlake, p. 133. Notes from a German manuscript in the Public Library in Strassburg.

have been made since those days, it behooves us to look into the materials and pigments that were used, and as there is no need for any improvement in the matter of pigments, it would be very well to stick to the old ones.

If we go back 2000 to 3000 years we find that the pigments used by the Egyptians, Phoenicians and those described by Pliny were practically the same as those that were used by the painters of the fourteenth, fifteenth and sixteenth centuries. In every case native earths were used, although it is likely that zinc oxide was a manufactured pigment in the time of Pliny, it having been collected in the furnaces where zinc was melted. But the media used before the discovery that oil could be used in painting, had much to do with the permanence and brilliancy of the colors, for assuming that the principal media in those days was always water with a glutinant such as the white of egg, glue obtained by boiling parchment in water, or some similar adhesive material, there was no re-action between the colors when they were dry, so that we have many examples of brilliant tempera paintings that are 600 and 700 years old. The Flemish painters as well as the Italians confined themselves to very few colors, and all the colors used by the painters prior to the time of artificial chemical colors are included in the following list:

Red: Sinopia, or cinnibar, which is the same as our vermilion, but inasmuch as the native sinopia was used, a variety of shades were obtained by selecting ores ranging from orange to a very deep red.

Red oxides of iron, which were native, and burnt ochres and burnt siennas. The burnt ochres and burnt siennas are all equivalent to the Mars colors of to-day.

Yellow: native ochre, native sienna.

Green: powdered malachite, terre verte or green earth.

Brown: native umber and bituminous earth similar to cassel brown, vandyke brown, etc.

Black: burnt ivory, charred bones and condensed soot (lampblack).

White: plaster of Paris (gypsum), whiting (calcium carbonate). These two were used for gesso painting and later for oil painting. White lead (cerusite), zinc oxide moderately, and tin oxide, but from the evidence at hand white lead was used more than any other white pigment.

Blue: the principal blue used was lapis lazuli, which is identical with the ultramarine blue of to-day. This ranges in color from a sky blue to a deep ultramarine, and was selected according to shade.

It must not be inferred that all the pigments used by the painters of ancient times were absolutely permanent, for only those that have survived have been permanent pigments, orpiment, for instance, which is the tri-sulphide of arsenic, is a color which interacted with other pigments.

# Permanent Painting

A number of lakes were used which are the extracts of woods, as well as of plants, such as the beet and cactus and red berries, but none of these red lakes were permanent.

## CHAPTER III

## SINOPIA
## THE SEARCH FOR THE MASTERS' SECRET

MUCH time and thought has been expended upon the so-called search for the secret of the old masters. This search was probably started by Sir Joshua Reynolds, who had the idea that the permanence of the pictures of the old masters was largely due to some secret knowledge which they possessed of certain colors, and that the so-called sinopia of the old masters was a red which disappeared and had been duplicated after the sixteenth century. On the contrary it is quite certain that the early Italian and Flemish painters had no secrets. Their painting was conducted upon lines of common sense and intellectual investigation. Rubens, Rembrandt, Franz Hals and their contemporaries did not use over five or possibly seven colors, and the sinopia which they used was all of one origin. Sinopia is evidently derived from the word sinopis,* and means a red earth from which the name cinnibar has been derived. We have therefore the cinnibar or red earth which was well known as far back as the twelfth century, and was found in an Austrian locality

* Die Malerei der Alten, Johns.

now known as Idria, which at that time was a province of Venetia. In Spain * this pigment has likewise long been known and is still found there to-day. It occurs as a bright red earth varying in color from scarlet to deep red, which is nothing more nor less than quick silver vermilion in its native form, together with oxide of iron.

From analyses made by the author of fragments of paintings of the fourteenth century, bright reds are conclusively proven to be sulphide of mercury or vermilion. It is also well known that for thousands of years the Chinese either made vermilion artificially, or carefully selected the bright particles from their native ores, and that the Chinese vermilion was introduced into Venetia during the thirteenth century by Marco Polo. This celebrated explorer traveled eastward, and found the first passage to the Orient. However, as the first authentic biography of Marco Polo was written by John Baptist Remusio 200 years after Marco Polo's death, there is some doubt as to some of the details of his trip. So we have, not only the introduction of the artificial and natural Chinese vermilion into Italy during the thirteenth century, but we have the Spanish ores of Almaden, and ores from the mines of Idria, from which all shades of bright red were selected for the production of this so-called sinopia, which was supposed to have been the brilliant and permanent red which was one of the causes of

* The Almaden Mines.

the superiority of the lost art, and one of the alleged great secrets of the old masters.

In examining a piece of ore from the Idria section, it is noted that many bright shades of red may be extracted and as sulphide of mercury when properly varnished and not exposed to brilliant sunshine does not change, we have a satisfactory explanation of the celebrated permanent red.

There is no doubt that in addition to using this red as a body color, hundreds of artists glazed this natural or artificial red with madder lake, and the condition of paintings of Franz Hals and his contemporary school is evidence of that fact.

Some statements have been made that sinopia is a color redder than vermilion, and was made from madder, but as vermilion or cinnibar is composed of all the shades of red from minium to deep scarlet, and as madder was known during that time, it is more than likely that the madder was used either as a glaze or mixed with vermilion, and in either case it was permanent, because all of the painters of that time varnished their pictures.

Some statements have been made referring to madder as a Brazil wood lake, and Eastlake makes the statement "Lignum brasilium nascitur in partibus Alexandriae et est rubei coloris." Brazil wood has its origin in a part of Alexandria, and is of red color; but inasmuch as Brazil was neither discovered nor exploited for several centuries afterwards, this statement must be taken to refer to some particular wood which was called Brazil wood, and which was indigenous to the country around Alexandria, and cannot be confounded with the Brazil wood we know, which produces a maroon dye that is exceedingly fugitive.

As far as the secret of the old masters is concerned, it would be very wise for modern painters not to waste their time in a search of this kind for these old masters whose pictures have lived to this day, were possessed of only one secret, which was common sense.

## CHAPTER IV

## PHOTO-CHEMICAL DETERIORATION OF OIL PAINTINGS *

ALL oil paintings show unmistakable signs of age. Students who visit the various art galleries and copy old oil paintings invariably glaze them with a lake color or asphaltum, so that the lighter colors are toned down and show a yellowish brown tinge, which to all of us is an unmistakable sign of age. The cause of this deterioration is nowhere in the entire literature of oil paintings, as far as the writer could learn. A number of writers have all suggested a remedy, which suggests the causes, the remedy given being the exposure of a painting to bright sunlight. The change in color is always more apparent in the high lights, and where light tints have been used, and inasmuch as water colors, pastels, and tempera painting do not show this particular deterioration, it is quite evident that the cause does not lie in the pigment itself, nor in the sub-stratum upon which is painted, but in the medium which is used to bind the pigment to its foundation. In search-

* Read before the 7th International Congress of Applied Chemistry, London, May 28, 1909.

ing for the cause, an analogous condition exists on walls of buildings which are painted in oil paint, for it is always apparent that where the sun shines on a wall it either retains its pristine color or becomes more brilliant. Similarly, back of the picture there is a distinct yellowing or browning of the pigment which gives a clear line of demarkation where the picture hung. Another piece of evidence is the fact that no such yellowing occurs where walls are painted with distemper or water colors, but this particular reaction is apparent in every instance where oil pigments are used. After finding the cause the task of finding a remedy was more simple. A series of experiments were tried by the author in the following sequence, and with the following results:

That the cause is what may be termed the effect of light on a mixture of white lead, zinc oxide and linseed oil, or a linseed oil varnish is evident because paint chemists have long known that white lead in any form, whether it be called flake white, kremitz white, silver white or white lead, has a reducing action on the pigment present in linseed oil, or linseed oil varnish, and that this reducing action changes this pigment into another pigment which is yellow. It may fairly be asked whether such a reaction can take place if the linseed oil is bleached. To this question the reply must be given that the bleaching of linseed oil does not destroy the color which is present, but simply changes it from an olive yellow to an exceedingly pale yellow, which can hardly be seen, so if we take refined or bleached linseed oil and mix it with white lead or a pigment containing white lead or zinc oxide, we have a very brilliant white which remains white as long as it is exposed to bright light. If we take this mixture and place it for six weeks in an absolutely dark place, the white paint changes into the well known yellow tint and it is this particular change which produces in all paintings the distinct yellowness of age. Flaxseed, from which linseed oil is made, contains a coloring matter which is known as chlorophyll. This is the same coloring matter which is found in all plants, in many of the woods and in a large number of gums and resins, particularly in the fossil resins.

Vibert, the well known French painter, knew this fact without having been able to trace it to its chemical cause, and this led him to abandon entirely linseed oil as a binding medium and to substitute petroleum and colophony compounds with which he painted most of his pictures. Nearly all of his subjects contain little or no light colors, such as whites or straw colors, but as his particular forte lay in painting pictures of cardinals, the original brilliancy of his paintings still remains, and there is no reason why his pictures should not endure for centuries, if they are properly protected from any influence of the elements and obnoxious gases of modern civilization.

A long series of experiments were, therefore, made and commercial chlorophyll, which is the coloring matter of flaxseed, grass, and the fossil resins, was taken and mixed with white lead and zinc oxide (zinc white), exposed to the sunlight for a short time and then placed in a dark closet for varying periods from six weeks to three months. In every instance the white turned yellow; sometimes a bright canary yellow, sometimes a dirty yellowish brown, but the yellow effect was always obtained. A similar line of experiments was made in which gum damar was dissolved in turpentine, naphtha and benzol, and the results carefully noted. Gum damar and turpentine showed only an exceedingly slight decomposition, and gum damar containing a small percentage of benzol and a large percentage of naphtha showed no decomposition. The human eye is not very sensitive to these shades, but fortunately we have the photographic plate. Photographs taken of these various mixtures on plates which are not over sensitive to yellow show up these results with better effect than the human eye can discern them in the original chlorophyll experiment.

Another line of experiments was carried out, in which bleached linseed oil was used. This turned exceedingly yellow in three months, but when exposed for three months to the bright sunlight it became brilliant white again, and upon being placed in a dark closet for another three months no change took place. Those parts of the painted experiment which had been bleached by the sunlight remained white in the dark closet at the end of the experiment. This would, therefore, prove that when a picture has turned yellow it can safely be exposed to the sunlight in order to bring it back to its natural brilliancy, provided, of course, that no part of it has been painted with asphaltum or bitumen, for the asphaltum and bitumen instead of bleaching in the light become black. To those who are interested in this photo-chemical experiment, the author refers to his paper on "The Influence of Sunlight on Paints and Varnishes," Journal Society of Chemical Industry, April 15, 1908, No. 7, Vol. XXVII.

Nearly all of the varnishes, with few exceptions, contribute largely to this deterioration of oil paintings, because the coloring matter in a dark place or away from the brilliant light changes from a neutral or invisible to a yellowish tint, which is due to a direct decomposition of chlorophyll into one of its lower bodies. A similar line of experiments were conducted with such resins as Manila copal, West Coast copal, and Zanzibar copal, all of which turned yellow even though no linseed oil was present. It is, therefore, easy to conclude that these and all fossil resins contain coloring matters similar to those present in grass, flaxseed, and in some instances, turpentine.

Furthermore, all of these fossil resins when used for making varnish are reduced or fluxed in a solution of linseed oil. The varnishes which, however, do not show this same effect are the alcohol varnishes composed of solutions of bleached shellac, sandarac, and mastic, although these show also some slight tendency toward turning yellow. The one resin which, however, resisted the action of darkening when mixed with white lead was gum damar. As there are three well known varieties of this gum used in the arts, the author has found that Batavia, Singapore and Pedang, when selected for brilliancy of color in their original state, are the safest to use, but there are varieties of these three gums which are originally yellow and should be avoided either as a varnish or as a medium for oil painting. The objection may be urged that the solution of gum damar is not sufficiently binding as compared with linseed oil, but to this the answer must be made that an oil painting is never exposed to the elements and is certainly more tenacious and less liable to decomposition than the media used by the ancients such as white of egg, mucilaginous matter, etc. We have authentic records where paintings executed by the Romans with poor and weak media have lasted for upwards of twenty centuries.

Of the solid white pigments, which induce the decomposition of oil and varnishes, white lead is the strongest in its action and zinc sulphide, or lithopone, is the weakest. It has been urged that lithopone, which is a mixture of zinc sulphide and barium sulphate—barium sulphate being the old permanent white or blanc fixe—should be substituted for all white pigments in oil painting, but this cannot be urged at present for the reason that the majority of the lithopones are acted upon by light and turn gray, although there are a variety of patents for the manufacture of lithopone which are alleged to be permanent. On examining these we find that their brilliancy is superinduced by the addition of a soluble salt such as nitrate of soda, and when lithopone, either according to the special American patents or the German patents, is mixed with gum damar solution no change takes place, but when mixed with linseed oil, either bleached or unbleached, the soluble salt produces the same effect as white lead in so far that it reduces the coloring matter from a neutral and invisible tint to a yellow or yellowish pigment, and, therefore, no advantage is gained at present by the use of this so-called permanent lithopone. Zinc oxide, or zinc white, is therefore, as yet, the most permanent pigment, although permanent white or blanc fixe is absolutely inert but it has the inherent weakness that it has no hiding power and is really more of a glaze than an opaque pigment.

However, if linseed oil is insisted upon by the painter the raw, unbleached, unrefined product should be used for it is reasonable to assume that it cannot grow any darker as long as the coloring matter is not visibly hidden, but may improve, for upon exposure the coloring matter will surely bleach, and upon replacing the painting in a poorly lighted room it will not grow any darker than it originally was when the painter used it. Some painters use poppy oil, which is almost colorless; other painters use walnut oil, but the author finds that while poppy oil and walnut oil are not so prone to become yellow with age, they nevertheless do become yellow and have in addition the fault of drying exceedingly slowly, which interferes largely with the progress of the painting. The driers that painters use are also to be avoided. The one color, megilp, which contains both lead and manganese, frequently exhibits a dirty pink, and the sugar of lead drier turns the oil yellow even quicker than white lead does.

Summing up the facts before us, it is reasonable to conclude that in order to make a painting permanent a medium like damar or mastic varnish, which has back of it a long history and is not experimental, may be advocated for general use as a varnish with which to glaze a painting and preserve its permanency. It has very few defects and much in its favor. In looking over the works of the Flemish artists, particularly those by the Van Eycks, which may be seen in the London galleries, it is quite evident that all these painters used a medium other than tempera. It is exceedingly likely that the medium contained little linseed oil, and possibly a varnish composed of an easily soluble gum, either like damar or mastic.

## CHAPTER V

## THE CAUSE OF THE CRACKING OF PAINTINGS AND THE REMEDIES

IT is very interesting to note that the little which is written on this subject varies with the actual facts presented in the case, and in addition is relatively incomplete. Nearly all writers give, as the cause of the cracking of paintings, two or three ordinary phenomena, when, as a matter of fact, the cause of the cracking of paintings may be due to a large variety of causes. The following are the principal causes for the cracking of paintings:

1. The application of such pigments as, for instance, umber or zinc white over lampblack, graphite, black lead, asphaltum or lake.

2. The application to a picture of a varnish over a surface that has not been thoroughly dried.

3. The effect of dry atmosphere on a painting, which contracts the canvas and leaves the paint film in its original size.

4. The unequal tension or compression of a canvas due to moisture.

5. The application of a flat drying paint over a glossy paint.

*Photo-micrograph of a section of an oil painting showing cracks. A. A. is a photograph of the warp of the canvas. The oblong white surfaces are thin films of paint which are cracked through tension and drying.*

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2. The application to a picture of a varnish over a surface that has not been thoroughly dried.

3. The effect of the atmosphere on a painting, which constantly [illegible] and leaves the paint film in its original [illegible]

4. [illegible] vas [illegible]

5. The application of a fast drying, [illegible] over a glossy paint.


A
A

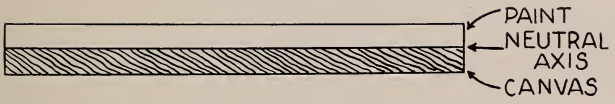
6. The application of megilp over a soft ground.
7. The use of bitumen as a glaze.

1. We learn from practical painters who apply colors and varnishes to the surfaces of carriages, automobiles and railway cars, that a proper ground must be prepared so that each coat will be dependent upon the other, and that the priming coat shall be harder than the layer above it. Practical painters, however, never have surfaces like canvas to paint, excepting when these surfaces are directly applied by means of a glutinant to a wall or similar foundation. We notice, even in the climate of North America, where the temperature variation is about 130° F., that the paint film on nearly all vehicles is permanent without cracking or peeling for several years. The principal cause is that a priming coat is applied of a hard drying paint which is rubbed down so as to present a smooth and uniform layer, and that a gloss coat is never placed over a gloss coat, but a gloss coat is always applied over a flat coat, in which case we have what is known as a "mechanical bond."

Canvas made of linen is exceedingly susceptible to the influence of moisture, and prepared canvas is generally sold with a coating that is sufficiently flat and has a better grain so that the first layer at least takes good hold. In order, therefore, to prevent cracking and to remedy it when it has taken place, it is essential to apply a good coat of paint on the back of the canvas, or to mount the finished picture upon another sheet of canvas which has been previously painted. The paint which has been found most suitable for the prevention of the absorption of moisture by a finished picture, and which in many instances will close up minute hairline cracks that have already started, is a mixture composed of one pound of red lead, dry, one pound white zinc, ground in oil, thinned with sufficient raw oil and turpentine to make a ready for use paint, having the consistency of cream. This mixture cannot be kept ready for use, because the red lead will combine with the oil and form a species of cement which dries very hard, and yet has some flexibility. The application of such a mixture to the back of a canvas makes it impervious to moisture and atmospheric influences, and preserves an otherwise weak painting.

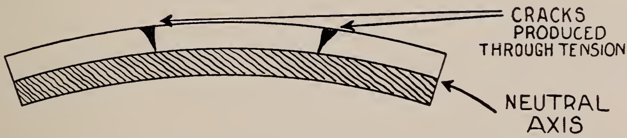
When the cracking occurs through the influence exerted on the back of the canvas, it is due absolutely to an engineering condition which is known as "compression and tension." The accompanying diagram illustrates this fact, so that we may have cracking which is entirely due to a curvature of the painted surface which is known as tension, or a compression of the canvas side, which is known as compression.

The artistic painter can demonstrate this for himself, if he will take an ordinary kodak film, which is perfectly flat, and paint one side of it with a mixture of, say, zinc white or reduced with turpentine only, A



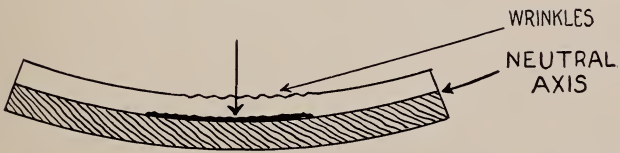

*The Engineering features of a painting at rest in which the centre line is the neutral axis.*

B




*The canvas in compression and the paint in tension, the tension producing cracks owing to the expansion of the paint films.*

C




*The paint in compression and the canvas in tension, which is the cause of paint films being forced from the canvas as indicated by the arrow.*

fasten it to a board so that it will not curl, and when it is dry, bend the surface which has been painted in an outward direction, whereupon he will find that the painted surface will show minute delicate cracks, which explains the theory of tension, and the theory of compression. The side in tension which is the painted side, invariably cracks. This then goes far toward explaining why pictures painted on metal or on wood have stood for centuries and have not cracked, and why unprotected pictures painted on canvas have cracked. Even wood panels are better protected when they are varnished on the reverse side than when they are permitted to warp.

The author cites as an illustration a painting by Michau on an oak panel which had for two centuries remained evidently in a perfectly flat condition in Belgium, but became badly warped when brought over to America, and only the application on the edges and the reverse side of two coats of the red lead and zinc paint, prevented what might have been a bad cracking of the panel itself. The climate in the winter in the United States shows an abnormally dry condition, and in the summer an abnormally moist condition, so that a painting which will curve outwardly in the winter through the contraction of the underside, will curve inwardly in the summer time, and this alternate bending inwardly and outwardly would eventually show some cracks.

2. One of the most fruitful surfaces for the crack-

ing of pictures is the varnishing of a picture before it is dry, and complaints are frequently heard that some varnishes are less liable to crack than others. This is largely the case with the alcohol varnishes which show a tendency to crack, and owing to their brittleness they should only be used under certain conditions. As the alcohol varnishes dry by evaporation they dry very rapidly. Many of the paints expand in the drying and some few of them ultimately contract, so that in either case varnishing even after apparent dryness with an alcohol varnish will produce very bad cracks. It has been generally stated, as an axiom, that a picture should be six months old before it be varnished. This is merely an arbitrary figure, and in every instance it is far better to wait a year if it can be conveniently done, than to varnish a picture in six months. Where, for instance, a very slow drying pigment like any one of the lakes, lampblack, black lead, etc., are used, and the picture is varnished before these pigments are thoroughly dry, cracking is bound to ensue. We therefore have the familiar phenomenon of a varnished picture which cracks in some places and is perfectly intact in others. This is due entirely to the so-called selective drying of the pigment itself. It is therefore wise under any circumstance to expose a picture to a current of air and to the bright light before varnishing.

3. This can always be obviated by properly painting the underside of the canvas. Where a painting of the underside is not desirable, the picture can be

mounted either upon metal or upon another stretch of canvas by means of a mixture of white lead and Venice turpentine.

4. The climatic influence which has been previously described, and which will cause cracks particularly on canvas, is more noticeable in climates like those in the eastern part of the United States than it is in Germany or England where the atmosphere is relatively moist the year round. Paintings can be best preserved in any climate when they are properly protected against dampness or dry air. If the material upon which the paint is applied had the same expansion and contraction which is technically called "coefficient of expansion," as the pigments themselves, there would be no trouble from this source, but the paint film of an oil painting is exceedingly slow to absorb moisture, and when the air is dry it gives up the moisture just as slowly, whereas canvas absorbs very readily and dries out very readily. Wood, particularly dry wood, absorbs moisture readily but more slowly than canvas. There are a large number of old paintings on copper which have been technically preserved for many centuries, so that where a painter can use either well seasoned wood or copper, it is advisable to do so.

5. In the proper chapter (see page [illegible]) the relative drying qualities of paints are given, and it is wise for the painter to follow the rules laid down.

The following experiment will illustrate a fruitful

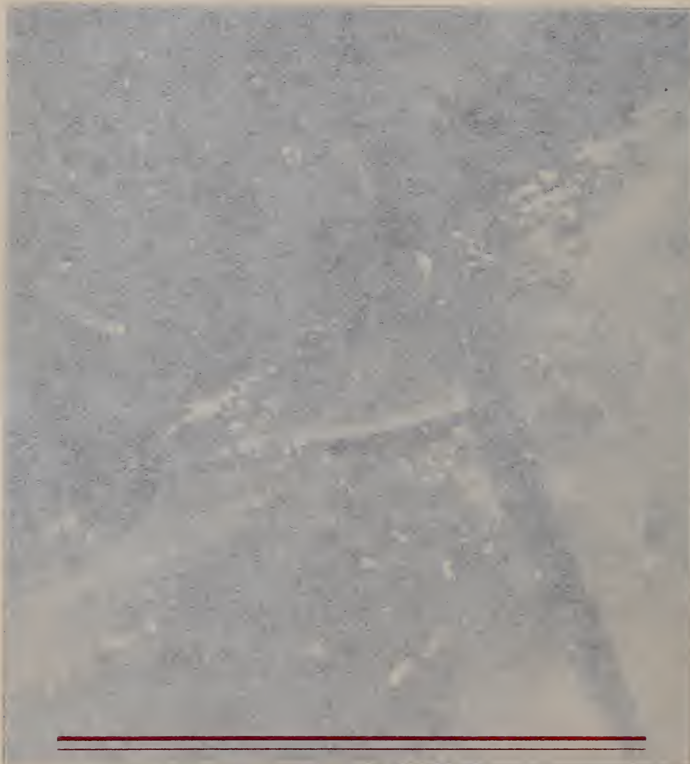


*Photo-micrograph of cracks in a painting, and dirt or dust encysted in the varnish. These cracks are open fissures.*

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The following experiment will illustrate a fruitful source of cracks in painting and many other pigments will act in a similar manner to a greater or lesser degree. Materials like minium, which is red lead, or burnt umber, dry with great rapidity, particularly when turpentine is added. Apply either one of these pigments over a ground work of pigments composed of lampblack or a lake, and it will be readily noted that within two weeks the top coat will contract and the bottom coat will expand, so that, because these two pigments do not dry co-ordinately, cracks will develop and the surface will resemble alligator hide, sometimes minutely, and sometimes with scales almost as large as those of the alligator hide itself.

6. The use of megilp.

This refers to the previous paragraph, and comes under the same heading, for megilp is a powerful oxidizing agent, and will produce a cracking when mixed with any pigment if placed over a soft drying ground. The same phenomenon results if megilp is used excessively with even a slow drying color such as madder lake or lampblack. Megilp, irrespective of this fact, is a material which should not be used by any painter, for in addition to its rapid drying qualities, it has a destructive influence on many of the finer colors.

7. Bitumen as a glaze has been productive of more damage than painters are aware of. It will produce cracks over almost any pigment to which it be applied, for it dries principally by evaporation, whereas

the ground upon which it is placed dries by oxidation. Its photo-chemical defects have been described under the heading of asphaltum, page 89, and need not be repeated here, but its physical defects are so patent, and it has been productive of so much disaster in the production of cracks, owing to unequal tension which it produces, that it should never be used.

## CHAPTER VI

## CANVAS, WOOD AND METAL AS FOUNDATIONS

IT is obvious that the best foundation for any picture is a sheet of metal. The next choice is a panel of oak or mahogany thoroughly seasoned, and last and least, a stretch of canvas. Copper has been used for centuries as a foundation for pictures, and as such cannot be improved upon, particularly if the copper be rolled out sufficiently thin and fastened to a well seasoned piece of wood. Next in choice and perhaps just as good, is zinc, but as both copper and zinc are exceedingly smooth, it is always advisable to roughen the surface by means of sand or emery powder, which gives it the appearance of ground glass, after which it takes the first coat of paint with perfect ease.

If artistic painters would only follow the precept and experience of coach painters, who, from time immemorial have followed the same rule, pictures would be much more permanent and less liable to crack. The coach painter, and in this category must be included the railway car painter and the automobile

*Painting on mahogany panel showing serious cracks produced by varnishing the picture before the underlying coat was sufficiently dry.*

*(Painting in the possession of the author.)*

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If easel painters would only follow the process and experience of coach painters, who, from time immemorial have followed the same rule, pictures would be made more permanent and less liable to crack. The coach painter, and in this category must be included the railway car painter and the automobile

painter, prepare the metal or wooden surface by first rubbing with sandpaper, emery cloth or pumice stone. Any imperfections in the surface are generally removed by the application of a first coating of what is known as "rough stuff." Rough stuff may be a finely powdered mineral such as slate or silicious clay, to which a little lampblack and white lead is added. The medium is not oil but Japan varnish, which is composed of a hard, quick-drying varnish containing very little oil. After two or three days, or sooner, this coating is sufficiently dry to be rubbed again, and a coat of white lead and lampblack is then applied, or pure white lead mixed with the same Japan varnish which is known as "Gold Size Japan," or "Coach Makers Japan." After this second coat is rubbed it presents a good surface for subsequent painting, which is exceedingly hard, but yet not brittle. This description refers, of course, to painting on a solid foundation like wood or metal, for on canvas such a treatment is ill advised owing to the unequal expansion and contraction between the canvas and the hard coating of such a priming paint.

From experiments which the author has made, it would appear that a sheet of aluminum $\frac{1}{16}$ of an inch thick rubbed with either linseed oil and finely powdered emery, or with pumice stone and water, presents a surface upon which a mixture of zinc white and white lead may be applied, forming a surface most desirable for subsequent painting, and giving a film which should be permanent for all time. Under no circumstances should the priming coat of any picture dry with a high gloss, otherwise no union takes place between the film of paint and the metal to which it be applied. The unequal expansion between an elastic coat and a rigid metal are very undesirable, but in spite of any good advice that may be given on this subject, painters will continue to paint on canvas, and such being the case, the best advice to give is to follow the precepts of the old Flemish painters, and paste the canvas either on a wood or metal foundation with white lead and Venice turpentine.

Where canvas is mounted on a wooden stretcher, and is sufficiently dry, the best application for the back is a hard drying semi-elastic paint, composed of red lead, white lead and zinc oxide, raw oil and turpentine. This should be applied until a thick glossy coating is obtained. Such a coating prevents cracks, and inhibits any chemical action through the underside of the canvas.

The purchase of ready made canvas is not always to be recommended. This statement refers to the canvas ready for immediate painting. Where a painter has the time a canvas may be purchased mounted upon a proper stretcher and treated in the following manner: A first coat of white lead is applied to the front and back of the canvas, and then a second coat of zinc oxide on the front of the canvas is properly rubbed down and smoothed. This makes an admirable surface which has sufficient tooth to take subsequent coats.

It has often been advised to prime canvas with a glue size, but the glue is continually subject to the influence of moisture, which it will absorb on a damp day and release again on a dry day, so that continual contraction and expansion take place, which is one of the causes of the cracking of paintings. A good hard coat of paint composed of white lead, more zinc and coach painter's japan properly applied to the surface of canvas will, in a few days, lay the lint sufficiently hard so that it can be sandpapered smooth. The next coat, which should also be a coat that does not dry glossy and that contains sufficient turpentine, will make a perfectly smooth foundation, and a paint of this sort is less subject to expansion and contraction than one painted on a glue size. Any painter can prepare a dozen canvases after this method, and if they are placed in the sun and allowed to ripen with age, they eventually become hard without becoming brittle.

For a canvas which is to be rolled up, a totally different method must be pursued. Such a canvas must have a very flexible foundation, and this can best be obtained by using raw linseed oil with a mixture of white lead and lampblack as a first coat. This mixture will take several days to dry. It should be very thinly applied, each coat containing less lampblack until a white surface is obtained. The rear side of the canvas where it is to be rolled up, should be treated solely with a coat of raw linseed oil and nothing else. A canvas so treated will remain flexible for many years.

## CHAPTER VII

## PREPARATION OF CANVAS IN COMMERCIAL PRACTICE

CANVAS for oil painting is stretched upon large frames, and receives a sizing coat of glue and water. After this sizing coat is dry, three coats of white lead in oil slightly tinted with black to produce a gray color are applied. The first coat is generally a very thick mixture of lead, oil, turpentine and drier which is applied to the canvas by means of a stick, and then scraped off with a curved steel knife. This is done for the purpose of pressing the material into the fibre of the canvas, and likewise for the purpose of producing a perfectly smooth surface. The two following coats are usually applied by means of brushes, and the material is thinned down with turpentine so that it will dry perfectly flat. The canvas is then stripped from the frame and rolled up, and after a few months becomes decidedly brittle. Up to date there has been no improvement in the preparation of canvas and it is difficult to believe that in this age of progress the preparation of canvas is still a hand-made procedure. Canvas ought really to be coated on both sides, and the coatings should be so very flexible that the question of cracking when the canvas is rolled up should be entirely eliminated.

The use of wood panels is not to be recommended in America, unless the wood is thoroughly seasoned. After it has been seasoned and planed, it should be allowed to soak for several weeks in a linseed oil varnish in order that it may absorb sufficient material to prevent future warping. The hygroscopic conditions in America are totally different from those prevailing in Europe. In Europe a painting on wood will remain perfect for centuries, because the amount of moisture in the air remains fairly uniform for a given locality, but even on the sea coasts in the United States the moisture conditions in the atmosphere vary so remarkably that it is below normal in the winter time, and above normal in the summer. Humidity in the atmosphere is generally expressed by arbitrary numbers, 100 representing a saturated condition of the atmosphere during a rain storm. Fifty is exceedingly dry, but in the winter on a clear day the humidity in the atmosphere is expressed by the figure 30. In such an atmosphere materials may be said to be anhydrous.

An oil painting on wood, unless it be properly protected either by successive coats of paint on all sides, or has been previously soaked in oil, varnish or shellac, will warp in the winter time with a curvature on the side of the painting, the reverse side being convex.

The result is that the obverse or painted side becomes cracked.

It is therefore preferable to paint on metal or on the composition known as academy board, which is a wood pulp or paper surface formed by cementing together several thicknesses of pasteboard or cardboard, and applying a coat of oil paint on what ultimately becomes the obverse side.

## CHAPTER VIII

## RENOVATION AND CLEANING OF PICTURES

THERE is perhaps no subject on which so little is definitely known as the renovation or cleaning of oil paintings, for the reason that no set rules can be given. It is essential that anyone who attempts to clean a picture should have some knowledge of the pigments, oils and varnishes that were used; otherwise good results are not obtained, and in many instances the painting is ruined. If we attempt to clean a picture with soap and water, which is very frequently done, and it happens to be an old painting of the tempera type, soap and water would dissolve the entire picture with ruinous results, but if the painting is made on wood or metal such preliminary cleaning can be resorted to, but no strong friction or attrition should take place on account of the danger of abrasion. If, on the other hand, we attempted to clean a picture with wood alcohol and turpentine, and it were painted with the same colors and media used by Vibert, and recommended by him, the picture would be almost instantly dissolved and effaced from its canvas. It therefore becomes imperative to experiment on the edge of a picture, preferably that part which is usually protected by the frame, with various solvents, in order to determine exactly what will take place.

As far as the remedy for cracks is concerned, the reader is referred to the chapter on "The Cause of the Cracking of Pictures; Its Prevention and Remedy." Therefore, this chapter will only deal with renovation, and it is assumed that the person who attempts to clean a painting is familiar with the materials used, and inasmuch as perhaps ninety-nine paintings out of one hundred that look like oil paintings are oil paintings, the remedies given by the author are for this class of pictures entirely.

The first essential is to determine the mount, whether it is wood, academy board or canvas. If it is canvas, two courses may be pursued; first, paint the back of the picture (see page 41), or second, mount the canvas with a mixture of white lead and Venice turpentine on another canvas. There are a large number of chemical solvents which remove old varnish, but these should only be used by a skilled operator. The most important of these chemical solvents are acetone, benzine, naphtha, benzol, amyl acetate, amyl alcohol (fusel oil), ethyl alcohol (grain alcohol), terpineol, methyl alcohol (wood alcohol), and various mixtures of these substances. The least harmful and the weakest is ordinary benzine, such as is used for cleaning gloves and garments, but it is not sufficiently strong to dissolve old dried cracked varnish. At the same time, a solvent which is strong enough to dissolve cracked varnish may likewise be strong enough to destroy the painting itself. Whether the picture is varnished or not, ordinary wood alcohol is taken either on a clean cotton rag or a sponge, and lightly rubbed in one corner. If it be varnished, the wood alcohol will very likely dissolve the varnish without touching the painting, but if there is any difficulty in dissolving the varnish, a mechanical mixture of turpentine and wood alcohol would have to be used, and as a general rule this will take off all the varnish. Forcible abrasion must never be resorted to, for any wet rag will, as a rule, take off some of the paint. The dried linseed oil or other drying oil film is not soluble in turpentine, but is attacked by wood alcohol after prolonged use. Therefore, if pure turpentine will cleanse a picture, it is wise to let it go at that, and as a general rule, assuming always that the picture is an oil painting, a stiff brush will very frequently aid in cleansing almost every part of a picture without the addition of wood alcohol, so that we have here only two re-agents which are necessary. It is necessary to warn everyone not to try the so-called paint removers, benzol or carbon tetrachloride mixtures which are sold, because in many instances the use of these materials is very harmful because the solvent action is entirely too great. Ordinary naphtha or gasoline, such as is used for cleaning gloves, can be very safely recommended, because its solvent action is not as great as that of turpentine and wood alcohol, so that, with the aid of these three materials, almost any varnish can be removed, and any adherent foreign substance easily washed off.

The use of soap and water is recommended by many, but this is always more or less dangerous unless the soap is absolutely neutral. It always finds its way into cracks, is absorbed by the canvas and the underlying paint, so that in many instances a painting becomes so badly buckled that, even though it is cleaned, the cracks and defects are magnified. (Great care must be taken not to use a soap which is alkaline. The soaps which are neutral are principally the shaving soaps, Ivory Soap, and genuine castile soap). The soap may be mixed with tepid water and applied with a sponge to the surface of the painting, thereby removing the thickened dust and dirt from its surface. An application of this kind will seldom, if ever, do any harm, except on a painting which is badly cracked, and where water is liable to soak into the canvas and swell it, or where the painting is based on an aqueous mixture.

Colors which have become darkened with age or affected by the sulphur fumes of the atmosphere, like flake white, and English or chrome vermilion, can only be properly renovated if the surface is abraded, and this can be frequently accomplished by means of a ball made of the inside of a fresh loaf of rye bread. The ball is gently rubbed on the picture after it has been cleaned with soap and water, and this is to be done in a good light. The rubbing given by means of the ball of bread will remove the outer layer and bring the color up to its original brilliancy.

It is essential that experiments be tried on a very small part, preferably in a corner or on an edge of the picture with various solvents, in order to determine whether any harm would be done or not. After washing a picture it may be rubbed with a clean woolen rag which has been dipped in pure spirits of turpentine, for spirits of turpentine will very often dissolve a varnish like mastic or damar but will not attack the dry linseed oil film of the painting beneath. The same may be said of benzine. A mixture of benzine and turpentine will frequently do no harm, but its application must always be followed by washing with turpentine alone. If thick films of varnish still remain, and are unattacked, they had better be left alone and the entire picture re-varnished with a harmless medium like damar or mastic varnish.

The use of stale bread handled as an eraser, or the use of soft rubber should not be resorted to, provided turpentine, benzine or wood alcohol will remove the surface dirt and varnish. Any form of abrasion may become a menace for the obvious reason, that, if on a flesh color madder lake was used as a glaze, it takes very little rubbing to remove the one one-thousandth of an inch of madder lake which has been applied for a given effect, and which when removed leaves a ghastly result.

Paintings that have turned yellow with age are best treated by first placing them in the bright sunlight for two or three days before the application or washing with turpentine. In many instances where a brilliant sky blue has turned to a dirty olive color, the sun will bring back much of the pristine brilliancy, and the rubbing with turpentine and a small percentage of wood alcohol will bring out the colors sometimes more brilliantly than they were on the day that they were applied.

Where sulphur fumes have decomposed the lead color and formed a brownish result, chemists have recommended the use of peroxide of hydrogen, and while this may be theoretically the proper method to pursue, it is not necessary, and sometimes dangerous, for the reason that even though peroxide of hydrogen will bring back flake white and chrome yellow to their original color, it may bleach an adjacent lake beyond redemption, and as these sulphur de-compositions of color are usually on the surface, the wood alcohol and turpentine treatment with very slight abrasion, will produce all the results necessary. The cleaning and renovation of pictures in the hands of an intelligent person is not a very difficult problem, but it is very easy to spoil any good painting by the use of nostrums and recipes which are destructive in their effect.

Very often a good picture assumes a bluish haze commonly called "bloom," which remains on it for years. It is due largely to the absorption of moisture by the varnish itself, and can easily be removed by a gentle application of two or three coats of turpentine, each successively wiped off and then finally varnished with a good hard varnish like amber or a mixture of amber, mastic and damar. Paintings that have been glazed with asphaltum must, however, be handled differently, for in the chapter on the "Asphaltum and Bitumen," it will be noted that asphaltum becomes darker with exposure rather than lighter, due to the liberation of carbon. This can be almost invariably removed by slight rubbing with turpentine and benzine, but inasmuch as it evidently was the artist's original intention to produce a different color effect by means of this glazing, the picture will have a totally different tone value and effect when the smut remaining from the asphaltum is removed, and the restoration of a picture of this kind should be given to some painter for re-glazing after the smutty residue of the asphaltum bitumen is thoroughly washed off.

After a picture has been thoroughly cleaned and bleached by means of sunlight, it is essential to varnish it immediately. Two coats of thin varnish properly dried, particularly where the second coat is ap-

*Photo-micrograph of cracks invisible to the naked eye showing encysted matter and fissures.*

use of nostrums and recipes which are destructive in many others.

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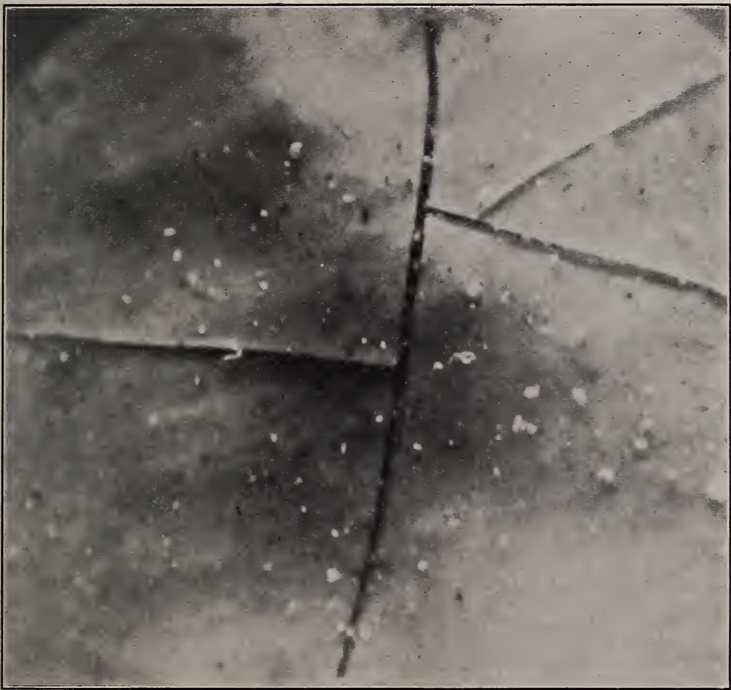

plied after the first coat is thoroughly dry, is by far preferable to the application of one heavy coat of varnish.

## CHAPTER IX

## THE SCHOOL OF IMPRESSIONISM

FROM time immemorial painters have depicted scenes as they saw them. A blue sky was painted with a mixture of white and blue. A sunset of yellow and orange was painted with yellow and a mixture of yellow and red. The principle upon which all painting is executed is that there are three primary pigments, red, yellow and blue, which, with the addition of white and black, furnish all the tints necessary for the production of any given shade, or mixture of complementary colors, so that if a green is desired, yellow and blue may be mixed, and if a light green is wanted, white is added, and if a dark green is wanted either more blue or black is added.

Without going into the discussion of the physics of this subject, it may be accepted that the result of the mixture of two pigments is a subtractive phenomenon. In other words, when yellow and blue are mixed, the yellow and the blue are simply subtracted from the white light which falls on them with the result that green is obtained, and carrying out this theory still further, if red, yellow and blue are mixed in their proper proportions, each of these colors is subtracted from the white light with the result that a pigment is obtained which produces an approach to black, and black is regarded as a minus or zero quantity.

In the blending of light we have the opposite effect, so that when we take three colored lights, or allow the rays which pass through sheets of glass composed of scarlet, green and violet, to impinge upon each other, we do not obtain a subtractive color but an additive color; that is, these three colors falling upon the same point form white. In other words, the sum total of the colored rays of scarlet, green and violet when added together are white, so that we have the phenomenon that the primary pigments mixed together form black, and the primary color sensations form white, and that the primary color sensations are not identical with the primary colors but lie between or adjacent to the primary colors of the spectrum. That is, the color sensations are scarlet, green and violet, while the primary colors are red, yellow and blue. The spectrum, as is well known, is composed of red, orange, yellow, green, blue, indigo and violet. The pigments may always be expressed in the form of paint and the color sensations may always be produced by light.

The Lumiere Bros., of Lyons, France, having worked upon the theory of the primary color sensations, developed the now well known process of color photography. They arranged close together colored starch grains tinted with transparent dyes, so that when these starch grains are viewed by transmitted light it is impossible to discern the scarlet from the green or the violet, the result being that the mixture produces what we call "white light." In photographing a yellow flower, and examining the yellow under the microscope we find that it is composed of equal parts of scarlet and green. True impressionistic painting is based upon this phenomena with the proper modifications for the obvious reason that it is practically impossible for any painter to put such small dots or points of pigments of green and violet so that when viewed at a distance they appear sky blue, and yet when we take green and violet light, or green and violet microscopic particles so small that the eye cannot deferentiate, the resulting color is sky blue, and not a mixture which the painter would expect it to be, because, as has been already explained, the mixture of pigments is subtractive and the mixture of light and light sensations is additive. If, therefore, on a gray or neutral ground, a painter will paint small patches of alternate pale green and pale violet and such a composite is viewed from a distance of fifteen or twenty feet or more, the resulting impression will be sky blue. True impressionistic painting is based entirely upon such phenomena.

There is one other influence which causes impressionism, which is due entirely to a defect of the eye. Those who have been in a photographic dark room, which is illuminated entirely by a red light, will have often noticed that upon emerging from the dark room into the white light, everything appeared green. This is caused by the fact that in the first place, the physical power of the nerve-fibrils of the eye which are sensitive to red are temporarily exhausted, and the eye sees only the complementary color which is green. If, therefore, a brilliant red sunset is painted by means of the massive application of scarlet and red, the foliage may be gray, but after viewing it steadily for a few moments it appears perfectly green, so that we have a green impression where it really does not exist, because the eye complements one color for another.

Unfortunately the theory of impressionistic painting has not been properly disseminated and not properly taught, so that we have some of the vilest and most impossible attempts at impressionistic painting which are based not upon science, but upon the fads which exist. Human beings are prone to say that they admire a daub because some one else who is supposed to know has pronounced it good, when as a matter of fact, it possesses no merit whatever, and its entire workmanship is so crude and so impossible that it would make little or no difference even if it were hung upside down.

There is a remarkable future for true impressionistic painting, but there is no future and no "raison d'etre" for the impossible daubs which masquerade under the name of impressionistic painting, and if a painter will study the theory as propounded by Ducos

Dunaron, which is not very difficult to learn, and will study the chemistry of light as propounded by Vogel and Rood, he or she will be able with a little practice to master the new branch of the art which is coupled with a science. The danger of applying masses of paint in promontory patches which are likely to dry rapidly and crack or peel have their own significance, for impressionistic painting may be plastic, but its plasticity should really be produced by means of light and shade effects.

## CHAPTER X

## VOLATILE SOLVENTS

THE two oldest solvents known are turpentine and lavender oil, but from the data at hand, it is very likely that lavender oil was known many centuries before turpentine. Chemically, lavender oil is analogous to turpentine, in fact, it is a species of turpentine containing an aromatic ingredient. Lavender oil is not used at present by oil painters to any great extent, but turpentine is largely used.

Vibert was the first great painter to recommend the use of benzine as a diluent for paint, and on this subject much is to be said. Vibert did not believe in the use of linseed oil, but used a resin varnish reduced with benzine. Benzine is nothing more nor less than the same material of lower gravity as what we know under the name of gasolene, petroleum essence, petroleum spirits, or naphtha, and is identical in chemical composition with the material used as a motive power in automobiles. There is another material which is spelled with an "e," "benzene," whereas the petroleum essence is spelled with an "i," benzine. The chemical name for benzene is benzol, but this is never to be recommended for oil painting, as its solvent power is much too great. If benzol (benzene) were used by a painter as a diluent over a freshly painted surface, it would dissolve the work of yesterday. For the purposes of uniformity, I shall refer to petroleum spirits as naphtha, which is the name by which it is best known in America. It has the advantage over turpentine that it evaporates much more rapidly, and leaves no residue, nor does it exert any drying influence by itself.

## CHAPTER XI

## PICTURE VARNISHES

THERE are on the market no less than nine different varnishes sometimes sold under fanciful names, out of which only three are recommended. The varnishes used are damar, sandarac, amber, copal, shellac, spirit varnish, oil copal and mastic. There may be some excuse for the use of spirit varnishes such as shellac or sandarac, which are made by dissolving these two gums in alcohol, and adding a small percentage of oil to prevent them from becoming too brittle. The principal advantage in using a spirit varnish is that it dries dust free in 10 or 15 minutes, but inasmuch as a spirit varnish binds very poorly on a linseed oil film, it is not to be recommended.

The use of oil copal varnishes, excepting where old paintings are to be imitated, is likewise to be deprecated, for no copal varnish which is made by fusing copal or kauri gum with linseed oil retains its original color, or absence of color. If a piece of wood is painted with flake white or zinc white and varnished with an oil copal varnish, it will be found that when it is placed in a dark closet, it turns a dirty yellow at the end of three months, and if the experiment is repeated, mastic or damar being used, it is found that no change in color takes place. Therefore, the only excuse for using an oil copal or oil kauri varnish is that if an old master is copied, the effect of time and the yellowing of age can be imitated. This can be best accomplished by the use of an oil varnish, and putting the painting away in a dark corner.

Mastic varnish is perhaps the most reliable of all. It is made by dissolving gum mastic in spirits of turpentine, this solution taking place in the cold and with occasional shaking. After the solution has been obtained, it is necessary to filter it either through cotton or filter paper. When placed away and allowed to ripen with age, it produces a flexible, glossy varnish, the life of which is generally conceded to be ten years.

Perhaps the next in the line is damar varnish, although this varnish is not as flexible as mastic, nor is the life of damar much over five years, but neither mastic nor damar turn yellow with age unless some drying oil is added to them.

Bleached and orange shellac when dissolved in methyl or ethyl alcohol have been used for many years as picture varnishes. Both of these varnishes are very opaque when made in the usual way, so that in order to clarify them, they are either filtered many times, or quick-silver vermilion is shaken with the varnishes, which after a day or two carries down the wax, and leaves a layer of clear varnish. This clear varnish is often sold under the name of French varnish, and is frequently mixed with either oil of lavender or oil of bergamot to produce flexibility. If progressive drying takes place under a varnish of this type, surface cracks are likely to ensue for obvious reasons,* and this is true of every varnish when applied before a painting be properly dry, but more so of the quick and hard drying varnishes.

There is much varnish sold under the name of amber varnish, which is made of a fossil kauri resin, and there is no doubt that the fossil kauri resin is superior to the genuine amber. It is a popular fallacy to suppose that the ancients used amber varnish, for it is very likely that they called all hard resins amber. True amber must be so thoroughly tempered with oil, and is so very difficult to fuse, and dries so very slowly, that its use is not recommended, and where it is properly fused it is almost black on account of the high heat necessary for melting.

The conclusion to be arrived at from the foregoing statements is that only two varnishes should be used for ordinary purposes, damar and mastic, and of the two mastic is preferable. It can be purchased from reliable firms, but where there is any doubt as to its purity, it can be very easily made by dissolving a pound of mastic in a quart of pure spirits of turpentine. When properly made, it has the color of refined linseed oil. It is better to use it in a thin layer than to make a thick solution and flow it on.

* See chapter on "The Cause of the Cracking of Paintings and the Remedies."

## CHAPTER XII

## DRIERS

THE use of driers in artistic painting is as someone stated "an invention of the devil." Copal megilp, which is merely super-saturated drying oil, has ruined many a good painting. There are circumstances where the use of a drier for artistic painting is permissible, such as, for instance, interior wall decorations where freedom from dust is essential, or for temporary painting for the purposes of reproduction for colored or black and white illustrations in books or magazines, but for portrait or landscape painting where the painter desires permanence, driers are to be deprecated.

The pigments themselves have peculiar characteristics in this regard (see chapter on "The drying qualities of pigments"), and the painter may help himself in case he desires a painting to dry rapidly, for if he has dark colors which do not dry, all the umbers and siennas are rapid driers, and if he has light colors which he desires to dry he may use in any instance spirits of turpentine and sunlight.

Turpentine is an excellent drier and perfectly harmless. It is quite true that it flattens the color, but this is no objection, because the free use of turpentine enables the painter to varnish his picture so much the sooner, and the use of sunlight is also of great assistance, for we have absolute evidence that zinc white, which is at first a slow drier, dries progressively until it becomes brittle, but may be made to dry rapidly in the beginning by simply exposing it to bright light. Ordinary zinc white when mixed with raw linseed oil and placed in the dark, will remain soft and wet sometimes as long as ten days, yet on a bright, clear spring or summer day when exposed to the bright light it will skin over and dry in 12 hours. Care, however, must always be taken never to expose a fresh painting to the heat of the summer sun, for linseed oil before it has begun to oxidize melts like wax. A current of air is likewise an effective drier, and some painters use the precaution of surrounding a painting with a curtain of cheese cloth which keeps the dust from it, but admits the air.

Driers decompose many pigments. In fact, nearly every one of the lake colors is rapidly affected by the action of driers. Madder lake, when mixed with a lead or manganese drier, soon loses its pristine brilliancy.

## CHAPTER XIII

## LINSEED OIL AND OTHER DRYING OILS

THE principal oils used by painters are linseed oil and poppy oil, and occasionally a little walnut oil. Linseed oil in its normal state is the best and the only oil that a painter should use. Walnut oil is paler than linseed oil, but dries much slower, while poppy oil is the palest of all the nut oils, and dries slower than walnut oil.

Linseed oil is the oil extracted from flax-seed and while there may be a great deal of talk concerning adulterated oils, it must be said in justice to the manufacturers of artists materials that in no instance has the author ever found a single sample of oil which was labeled linseed oil that contained any impurity whatever, so that it is perfectly safe for any painter to buy linseed oil from a credited manufacturer, and rest secure in the knowledge that the material is absolutely pure.

The great objection, however, to the purchase of the majority of samples of linseed oil for artistic painting, is that the oil is generally refined or bleached, which is a serious mistake. Refined or bleached linseed oil means linseed oil in which the color is hidden, for in the bleaching of linseed oil the color is not extracted, it is simply changed from a greenish color to a barely visible yellow. *

The point which the author wishes to bring out is that the painter is far better off, if he is going to use linseed oil for the reduction of his pigments, to use only raw linseed oil unbleached, but well settled. If the yellowish green, or the decidedly yellow raw linseed oil is used, the painter has the advantage in that the resulting mixture with white or light pigments will never grow much darker, and the highest tones that are produced are tones which the subsequent painting will show. On the other hand, if the bleached and almost colorless linseed oil is used, it cannot bleach any further, and if the painting is put away in a dark place, it is bound to grow darker on account of the generation of the original coloring matter in the oil. In other words, the coloring matter contained in bleached oil reverts with many pigments like flake white and zinc white to its original greenish state. Painters will do well to bear this in mind when painting portraits. The use of bleached de-colorized linseed, poppy, or walnut oils is to be deprecated under all circumstances.

Linseed oil dries much better in the sunlight than it does in the dark.

The recommendation which one reads quite fre-

* For a more scientific treatment of this subject, the reader is referred to page 32, on the "Photo-Chemical Deterioration of oil paintings."

quently, that a painter should press linseed oil for his own uses, is just as ridiculous in these days as the recommendation that a painter should grind his own colors. Pure raw linseed oil is obtainable in every civilized community, and what a painter should do is to buy a gallon of it, place it in small bottles which are corked only with a tuft of cotton and stand them on a shelf where they may remain for years, although it is unwise for a painter to use linseed oil which is more than five years old, because it is likely to decompose and become what is technically termed as "fatty," which is equal to a kind of rancidity that we generally associate with the edible fats. At the same time, linseed oil that has become slightly thickened with age is of great value when mixed with the drying pigments, such as zinc oxide and umber, because a film is obtained which is far more flexible than that obtained with the aid of driers.

When linseed oil is boiled it becomes very much paler than it is in its raw state. This may sound like a contradiction, because nearly all boiled oils are dark, but that is due to the fact that they are generally boiled with a drier like lead or manganese, and these metals go into solution and form chemical soaps which alter the color of the oil. Any painter may try the experiment himself by taking raw linseed oil, placing it in a clean agate-ware dish, and heating it slowly and carefully until it begins to froth. On cooling, it will be noted that the oil is somewhat thicker and very much paler, and in addition to this, it dries in much less time than it does in its raw state. Such oil should never be used with the quick-drying pigments, but may be very safely used with all the blacks, zinc white, permanent white and any of the lakes, but boiled linseed oil which contains an added drier like manganese, litharge, zinc or lime, should never be used with any lake pigment.

Linseed oil in the process of drying goes through a very peculiar transformation. It generates both carbonic acid and water.*

Even assuming that every pigment is dry when it is ground with oil for the painters' use, we can therefore readily see that if flake white is mixed with an ultramarine blue, a sulphide of lead is likely to result, owing to the generation of water in the actual drying of the paint itself.

The painter is probably aware of the fact that linseed oil, poppy oil and walnut oil, but linseed oil particularly, dry from the top down. In other words, a skin is first formed, and underneath this skin the paint remains soft sometimes for years. Graphite and lampblack show this peculiar phenomenon more than any other pigment. Either of these two will dry on the surface, and sometimes a year afterward will be soft and wet underneath the skin which has formed.

* To those interested in the chemical philosophy of this subject, the author refers the reader to page 82, "Chemistry & Technology of Mixed Paints," by Maximilian Toch.

Linseed oil increases in bulk when it dries, which means that it does not dry by evaporation like turpentine, but dries by what we know as oxidation. It absorbs oxygen from the air, and forms a material which is known among chemists as linoxin, and linoxin is nothing more nor less than dry linseed oil or oxidized linseed oil. A film of linseed oil paint increases in size depending upon the nature of the seed from which it is made, from 10 to 20%, which accounts for the wrinkling which very frequently takes place. To obviate this wrinkling painters do not add additional oil to their paint, but add turpentine, or benzine.

*Photograph of an oil painting showing serious cracking throughout, due to the contraction of the paint. Not sufficient sizing material had been applied to the canvas before the painting was executed, which is evidenced by the warp and woof of the canvas showing through the paint.*

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# CHAPTER XIV

## CLASSIFICATION OF THE PIGMENTS AND THEIR DESCRIPTION

The pigments which are in use, and a fairly complete list of those found on the market throughout the civilized world, are as follows:

**List of Colors**

Alizarin Crimson
Alizarin Orange
Alizarin Scarlet
Alizarin Yellow
Alizarin Green
Alizarin Carmine
Alumina White or Lake White
Antwerp Blue
Asphaltum
Aurelian
Bistre
Bitumen
Black Lead
Blue Black
Blue Verditer
Bone Brown
Brilliant Ultramarine Blue
Bronze Green
Brown Madder
Brown Lake
Brown Ochre
Brown Pink
Burnt Carmine
Burnt Roman Ochre
Burnt Sienna
Burnt Umber
Cadmium Yellow
Cadmium Yellow Pale
Caledonian Brown
Cappah Brown
Carbon Black
Carmine
Carmine Lake
Carnation Lake
Cassel Earth
Cerulean Blue
Charcoal Gray
Chinese Blue
Chinese Vermilion
Chinese White
Chrome Greens, 1, 2 & 3
Chrome Orange
Chrome Oxide
Chrome Red

Cinnabar Greens, 1, 2 & 3
Citron Yellow
Cobalt Blue
Cobalt Green
Cobalt Violet
Cologne Earth
Constant White
Copal Megilp
Cork Black
Cremnitz White
Crimson Lake
Crimson Madder
Davey's Gray
Deep Madder
Emerald Green
Extract of Vermilion
Field's Orange, Vermilion
Flake White
French Blue
French Ultramarine
French Vermilion
French Veronese Green
Foundation White
Gallstone
Gamboge
Geranium Lake
Geranium Madder
Gold Ochre
Green Lakes, 2 & 3
Harrison Red
Hooker's Green, 1 & 2
Indian Lake
Indian Purple (Oil)
Indian Purple (Water)
Indian Red
Indian Yellow
Indigo
Italian Pink
Ivory Black
Jacqueminot Madder
Jaune Brilliant
King's Yellow (Oil)
King's Yellow (Water)
Lamp Black
Leitch's Blue
Lemon Yellow
Light Red
Madder Carmine
Madder Carmine, extra
Madder Lake
Magenta
Malachite Green
Mars Brown
Mars Orange
Mars Red
Mars Violet
Mars Yellow
Mauve
Mauve Lake
Megilp
Mineral Gray
Minium
Monochrome Tints (warm)
Monochrome Tints (cool)

Mummy
Naples Yellow (Oil)
Naples Yellow, Light
Naples Yellow, French
Naples Yellow, Medium
Naples Yellow, Deep
Naples Yellow, Reddish
Naples Yellow, Greenish
Neutral Orange
Neutral Tint (Oil)
Neutral Tint (Water)
New Blue
Nottingham White
Olive Green (Oil)
Olive Green (Water)
Olive Lake
Olive Madder
Orange Madder
Orange Mineral
Orange Vermilion
Orient Madder
Orpiment
Oxford Ochre
Oxide of Chromium,
Oxide of Chromium, Transparent
Payne's Gray (Oil)
Payne's Gray (Water)
Permanent Blue
Permanent Green, Lt.
Permanent Green, Med.
Permanent Green, Deep
Permanent Violet
Permanent White
Permanent Yellow
Pink Madder
Primrose Aureolin
Primrose Yellow
Prussian Blue
Prussian Brown
Prussian Green (Oil)
Prussian Green (Water)
Pure Scarlet
Purple Lake
Purple Madder
Raw Sienna
Raw Umber
Rembrandt's Madder
Roman Ochre
Roman Ochre (cool)
Roman Sepia
Rose Doree
Rose Lake
Rose Madder
Rubens Madder
Sap Green (Water)
Sap Green (Oil)
Scarlet Lake
Scarlet Madder
Scarlet Red
Scarlet Vermilion
Sepia (Oil)
Sepia (Water)
Silver White
Sky Blue
Smalt

- Terra Rose
- Terre Verte
- Tours Red
- Tours Orange Mineral
- Transparent Gold Ochre
- Tuscan Red
- Ultramarine (Genuine)
- Ultramarine Ash
- Vandyke Brown
- Vandyke Madder
- Venetian Red
- Verdigris
- Vermilion
- Vermilion, pale
- Verona Brown
- Veronese Green
- Violet Carmine
- Viridian
- Warm Sepia
- Yellow Carmine
- Yellow Lake
- Yellow Ochre
- Zinc White
- Zinnober Green, light
- Zinnober Green, extra light
- Zinnober Green, Medium
- Zinnober Green, Deep

Later I shall attempt to separate these pigments into various classes. First, the pigments which can be indiscriminately mixed with each other, and will not interact and are not affected by light. Second, pigments which alone are permanent, but which cannot be mixed with each other. Third, pigments which are fairly permanent under normal conditions, but not permanent when exposed to strong sunlight. Fourth, pigments which are fugitive, and which should under all circumstances be excluded from the artist's palette, existing only for the purpose of illustration for half-tone color work, and for use in illustrations in magazines. Perhaps the only excuse for the use of the fugitive pigments is for the purpose just referred to, but even then every possible shade and gradation of color can be obtained by the use of the more permanent colors.

### ALIZARIN COLORS (RED)

The alizarin colors are identical in composition with all the madder lakes, and up to the last generation the madder root was specially cultivated for the purpose of making a permanent red lake. The growing of the madder plant and the extraction of the color from the root, was a great industry in France. The red trousers worn by the French military were dyed with madder, in order to give the proper impetus to this industry, but with the advent of the coal tar dyes, an artificial madder was produced which is known as alizarin. This is identical in every respect with the color extracted from the root of the plant. The botanical name of the plant is Rubia Tinctorium, and as such was known to the Flemish and Italian painters.

Alizarin or madder lake may be considered as a permanent color under certain conditions. Franz Hals was well aware of the correct way in which to use this lake in order to produce the vivid flesh tints of his countrymen. Rubicond noses and sunburnt cheeks were portrayed by him in a manner which after a lapse of three centuries have shown that this color, when intelligently used, is permanent.

If madder lake is used as a glaze over a color which has been allowed to dry thoroughly, it will remain permanent, but if madder or alizarin lake is mixed with any mineral or metallic color such as ochre, lead, sienna, etc., a chemical decomposition takes place, with the result that the lake is bleached. It is reasonable to suppose that Rembrandt did not glaze his flesh paints in the way that Franz Hals and Jan Steen did, as the flesh tints of the Rembrandt's of to-day are more or less bleached. The "Anatomy Lesson" in the Hague, shows upon close examination that the flesh tones of the demonstrator and the spectators have suffered from exposure to light, very likely due to the fact that the lake used in glazing was mixed with the under-coat. It is, therefore, reasonable to assume that alizarin or madder lakes should be used as glazing colors over a properly dried surface. Alizarin or madder lakes, however, will not decompose when mixed with various blacks such as black lead, ivory black, lamp black and carbon black.

Madder lake may be mixed with any oxide of iron color which has been burnt, but may not be mixed with any raw iron color. For instance, madder or alizarin may be mixed with Indian red, forming a color known as Tuscan red, which is perfectly permanent. It may also be mixed with burnt sienna, burnt ochre, burnt umber, etc., but is fugitive when mixed with raw ochre, raw sienna or raw umber. The chemical colors like flake white (white lead), zinc oxide, chrome yellow, Naples yellow and chrome green all bleach it, but colors like quick silver, vermilion, cadmium yellow and all of the blacks do not affect it.

The safest way in which to use it is as a glaze over a ground which is thoroughly dry. Madder lake deepens considerably when placed in a dark place, but is revived when subjected to bright sunlight.

### ALIZARIN YELLOW AND GREEN

These two colors are taken as one, for the reason that both alizarin yellow and alizarin green do not exist, all the alizarin colors up to date being of a red or maroon shade. The name, therefore, is a misnomer, and should not be permitted.

Alizarin yellow is a fairly permanent yellow lake made of an aniline yellow. There are, however, some alizarin yellows on the market which are made from the extracts of bark like quer citron, and these are not permanent. The author has made a yellow lake from the paranitraniline which is perfectly permanent when used alone, has great brilliancy and strength, but cannot by any means be called an alizarin yellow.

The same is true of alizarin green, which as such, does not exist, and all the so-called alizarin greens on the market are not permanent, but are green lakes made from coal tar dyes which readily decompose when they are mixed with ochre or any one of the oxide of iron colors. The use of both of these colors is unwarranted.

## ALUMINA WHITE OR LAKE WHITE

This is the hydrated oxide of alumina which is ground in linseed oil, and is almost as transparent as glass. It is simply used as a medium for reducing or attenuating other pigments as, for instance, when it is desirable to glaze with burnt sienna, it is of advantage to mix burnt sienna with alumina, because in that way the burnt sienna assumes all the qualities of a lake color. Alumina is permanent, and is not affected by other pigments. As however, the amount of oil necessary to grind alumina into the paste form is very large, the oil contained in the mixture is prone to turn yellow. It has a variety of advantages, however, which makes it exceedingly useful and can be generally recommended.

## ANTWERP BLUE

Antwerp blue is either a mixture of Prussian blue or Chinese blue with aluminum hydrate, in other words, it is a Prussian blue reduced with a transparent base, and is not to be recommended where absolute permanency is desired. Of itself, or when mixed with zinc white, it produces very beautiful sky blue shades, and if properly varnished and painted on a solid surface, such as metal or wood, shows no change for many years, but when Antwerp blue is mixed with flake white or zinc white and reduced with raw linseed oil, it turns decidedly green in a dark place, or in a poorly lighted studio, but regains its brilliant color when exposed to sunlight and air again. It is a weak form of Prussian blue used as a glaze, and is now superseded by ultramarine blue mixed with a transparent black.

### ASPHALTUM

This is the same as bitumen and is a black gum, varieties of which are found in Africa, Cuba and the United States. It is a great mistake for artists' material manufacturers to sell asphaltum or bitumen to painters or to carry it in stock, as it is not only worthless, but has a tendency to ruin a painting on which it is used. When mixed with other pigments, it retards their drying. When used as a glazing color, it is frequently a cause of so-called alligator cracks, owing to the unequal expansion and contraction between it and the base upon which it is applied, but the worst feature of it is that when it is exposed to sunlight, it decomposes into charcoal and water, and deposits a black soot on the picture. To those who are interested in a scientific dissertation on this subject, I would refer them to the article on the "Influence of Sun Light on Paints," Journal, Society of Chemical Industry, which systematically explains the effect of light on the hydro-carbon compounds, but as this is not a work on chemistry, the scientific illustrations will be omitted.

Asphaltum or bitumen is harmful in every sense of the word, and it is very doubtful whether the great masters ever used it. In Italy it was used to a greater extent than in Flanders, for there are still many old pictures to be found in Italy which are a black smudge with here and there a faint trace of lighter pigment. This black smudge was once a bright mass of colors glazed with bitumen, which can be revived by cleaning carefully with methyl alcohol.

A glaze which is permanent can be made in imitation of asphaltum by mixing raw sienna, burnt umber and carbon black or ivory black.

### AURELIAN

Aurelian is a pigment that has been introduced during the last generation, and is sometimes sold under the name of cobalt yellow. It is a double nitrite of cobalt and potassium. There is a variation of opinion as to its permanency. Some claim that it is absolutely permanent both in water and oil, and others claim that it decomposes with a white, but from the experiments made by the author its permanence depends entirely upon its purity. If the color is thoroughly washed by the manufacturer after it is precipitated in order to free it from soluble salts, it may be regarded as absolutely permanent, because it is not affected by sulphur gases nor by sunlight. If the color is impure, it is very likely to decompose any lake which may be added to it, and when mixed with raw linseed oil, it loses its brilliancy in a short time. There are several good manufacturers of this pigment, whose aurelian yellow may be used and regarded as absolutely permanent. For safety's sake, it is advisable to use it alone and not to mix it with any lake pigment. Lake glazed over it, after it is perfectly dry, does not affect either the lake or the aurelian.

### AURORA YELLOW (See Cadmium Colors)

### BISTRE

This is a species of lamp black, which is the soot from the smoke of pitch pine. In the condensation, a small percentage of resin is admixed which probably accounts for the brownish color of this soot. It may be regarded as permanent, but when mixed with oil dries very badly. It is a deep brown, but it has been asserted that better or more permanent effects can be obtained by a mixture of lamp black and umber. It is used as a water color as well as an oil color.

### BITUMEN (See Asphaltum)

### BLACK LEAD

This pigment is composed principally of graphite, which is the material used for making lead pencils. It is a form of carbon, and varies in purity from 60% to 90%, the other constituents being silica and clay. Black lead is popularly known under the name of "stove polish." It has a metallic steel gray sheen, both when used as a water color and as an oil color, and gives delicate grays which are free from blue. It is one of the permanent colors, and has absolutely no effect whatever upon any color with which it may be mixed. It is an exceedingly slow drier, and when it does dry it remains soft, so that care must be exercised not to use it too thickly, for, after it skins over and dries from the top, the interior may remain soft for years. In making a gray by mixing with zinc white, it has the advantage of neutralizing the eventual brittleness produced by the zinc, and may be regarded under every circumstance as a perfectly soft and permanent pigment. The hard drying colors such as zinc, red lead, orange mineral, umber, etc., should be used with great care over black lead, for the obvious reason that cracks are bound to result, owing to the non-equal tension in drying. *

### BLUE BLACK

This is a species of vine black and charcoal, and derives its name from the fact that when mixed with white, it produces a very pleasing bluish gray, which is absolutely permanent. Blue black is an excellent drier, in fact, so much so, that the pigment will sometimes dry up entirely in the tube. Blue black is slight-

* See chapter on the Cracking of Oil Paintings, p. 40.

ly alkaline, which accounts for its excellent drying properties, and likewise accounts for its livering in the tube. When once it has livered, it cannot very well be restored to its original condition. There are, however, a number of good lamp blacks on the market sold in tube form, which are as fine, if not finer, than blue black and produce practically the same shade.

Of the various samples examined, no two manufacturers appear to use the same material. In one instance, the author found the pigment to be composed of vine black, which is a species of charcoal. In another instance a very pure lamp black appeared to be the base, which when mixed with white tinted out to a relatively blue gray, and in a third instance, it appeared to be a mixture of charcoal tinted with Prussian blue. All three of these pigments may be regarded as permanent, for very particular uses in painting, particularly in landscape painting for producing sombre sky effects.

Blue black may be mixed with zinc in any proportion, and while it is not so slow a drier as graphite or lamp black, it has relatively the same effect on zinc and prevents it from becoming brittle.

## BLUE VERDITER

Blue verditer is the hydrated oxide of copper, but inasmuch as it is made by precipitating a copper solution with lime, it is not always permanent in the tubes, for it has the property of combining with the oil and stiffening into a livery compound. It is quite a defective color, and should not be used for permanent painting, for the reason that hydrogen sulphide blackens it and sulphuric acid bleaches it, and when it contains traces of lime it dries exceedingly hard and is liable to crack.

The same shade may be obtained by mixing such permanent pigments as ultramarine, zinc oxide and hydrated chrome oxide, these three being unaffected by sulphureted hydrogen.

### BONE BROWN

This is one of the pigments which has no license to exist. When bones are fully calcined they produce a very desirable black color, but when bones are partly calcined the color is brown, owing to the production of what is known as bone pitch. In chemical composition, bone pitch is the same as asphaltum, and this accounts for the fact that bone brown is a very bad drier and is not permanent to light. The same effects may be produced by the use of many other more durable colors. Bone brown should be stricken from the list of artists' colors.

### BRILLIANT ULTRAMARINE BLUE

Brilliant ultramarine blue is assumed to be the artificial ultramarine blue which is made by calcining sulphur, clay and sulphate of soda. It is permanent to light when used alone and when used with certain of the colors upon which it has no influence, and will be properly described under ultramarine blue.

## BRONZE GREEN

This is a mixture of orange chrome yellow and Prussian blue. When pure, it is not affected by sunlight, and when properly varnished, and protected is unaffected by sulphureted hydrogen.

There is, however, no reason why bronze green should be made from chrome yellow, as where possible all lead colors should be avoided by the painter. Cadmium yellow and Prussian blue make a very permanent bronze green which is permanent but more expensive than the chrome yellow pigment.

## BROWN MADDER

Brown madder differs nowadays from the brown madder made 50 years ago. Formerly the madder brown was prepared from madder root, and tinted with a solid pigment, such as burnt ochre or burnt sienna Brown madder is now made in the same chemical manner in which the red madder is made, with the exception that the color is practically spoiled in the making by the addition of iron oxide, because inasmuch as iron compounds exert a continuous reducing action on the pigment, brown madder soon loses its brilliancy and is destroyed. It may be regarded as a fairly permanent color, but can be replaced in several ways, and is therefore not to be recommended.

All the qualities of this pigment are described under the head of alizarin or madder lake. When mixed with a metallic color like lead, zinc or iron it is not permanent. When used alone and made of madder lake and lamp black it is permanent.

## BROWN LAKE

This may be any red or maroon lake of an organic nature either calcined the same as burnt carmine or saddened by the admixture of an iron compound. When made in the latter manner it is permanent for two or three years. When made in the former manner it is very fugitive.

Brown lake made by mixing madder lake and burnt amber is permanent and dries very well. Some painters make a perfect brown by mixing lamp black, cadmium and madder lake. This mixture is permanent, but has the disadvantage of drying very slowly.

## BROWN OCHRE

Brown ochre is similar in composition to all the other ochres, being a form of clay tinted naturally with iron ores or the hydrated oxide of iron. It is known also under the name of Oxford ochre, and sometimes deep Roman ochre, and when used alone is permanent, but when mixed with any white pigment it turns considerably darker after a lapse of several years.

Brown ochre must never be used with any lake color because the iron oxide in it has a destructive effect. It is a good drier, and when properly thinned out may be used as a glaze. It is analogous to raw sienna, but is considerably weaker in tinting power.

A very dark ochre may contain nearly 40% hydrated oxide of iron, whereas French ochres contain only 20%, and are therefore nearer in composition to siennas. It has a tendency, when exposed to strong sunlight for a long time, to darken, which is evidently due to the change in the oxide of iron. It is otherwise an exceedingly permanent color, but has a destructive influence on all lakes with which it may be mixed. It is a good drier.

### BROWN PINK

Brown pink is similar in composition to Dutch pink and Italian pink. It is a transparent olive yellow like all of its progenitors. It is made from either the Persian berry or quercitron bark, and when made from a vegetable coloring matter of this kind, has little or no value as a permanent pigment. It is very easily decomposed in the presence of many of the metallic pigments, and when mixed with zinc or used as a glaze will fade in the bright sunlight perceptibly in four weeks.

For experimental purposes, however the author has made a color of this nature on the paranitraniline series which, when used alone over a dry surface, is practically permanent and does not bleach in the light, but darkens very slightly. Brown pink after a year is useless as a permanent color and is not recommended. Neither can the transparent yellow made by the author be recommended at this writing, because the color has only been under observation for four years.

## BURNT CARMINE

Burnt carmine is made from ordinary carmine or carmine lake by heating it until the organic matter begins to char, so that what we really have is a decomposition of the color and an increase in the percentage of carbon. If you, therefore, take a lake and mix it with carbon black, you obtain practically the same results. At the same time, any burnt lake of the carmine or scarlet or crimson order is a fugitive color, weak in hiding power, poor in glazing properly, but effects are obtained which are regarded as desirable by some. A burnt lake should really not be used by any painter. It may be a very beautiful color, and it may possibly have some uses for interior decoration where brilliancy is not required, but from the standpoint of the artists' palette, it is unfortunate that this color was ever invented for a four weeks' exposure to the midsummer's sun decomposed it almost beyond recognition.

Any madder with a touch of lampblack produces the same result, and color manufacturers could produce such a combination under the name of permanent burnt lake.

### BROWN ROMAN OCHRE

This is a species of dark ochre obtained by burning the ochre and driving off the water which it contains, thus producing a rich brown which has some similarity to burnt sienna, but is very much weaker. It is a very permanent color. When mixed with whites it does not fade, but after eighteen months becomes slightly darker, if that term may be used in conjunction with it, but in spite of its darkening it loses none of its pristine brilliancy, and was one of the colors used by the early Italian painters with excellent results.

When ground in pure linseed oil, it has a tendency to harden in the tube, but may be broken up and used freely. It has very little hiding power, and may therefore be used as a glazing color. It has less effect upon the decomposition of madder lake than its unburnt progenitor.

### BURNT SIENNA

This is a material very much similar in composition to burnt ochre, excepting that its content of oxide of iron is very much larger, and the physical characteristics differ from those of ochre. Ochre is opaque and burnt sienna is translucent. Burnt sienna is one of the most permanent colors in existence, excepting perhaps, the lighter shades which have not been so well calcined, and these have a strong tendency to darken and become redder. As a glazing color, it has valuable properties, and it can be mixed with lake colors. Painters generally allow the sienna to dry thoroughly, and then glaze a lake color over it. Exceedingly rich tints are produced in this manner which are absolutely permanent, providing the lake itself is permanent.

The mars colors are nearly all artificial siennas and are just as permanent. Burnt sienna is an excellent drier and will mix with almost every other permanent color.

## BURNT UMBER

Burnt umber is similar to burnt sienna. It contains oxides of manganese and iron. It is made by heating raw umber, which is a dark olive green color, but when heated is converted into a pleasing brown. It is a permanent color, and one of the best drying pigments in existence; so much so, that many painters mix umber with their pigments for producing dark backgrounds in order to obtain a good drying surface.

Burnt umber has more hiding power (opacity) than the sienna colors and is perfectly permanent and reliable. Care must be exercised not to paint it over a soft or semi-dry ground or cracks will result.

### CADMIUM YELLOW

This description comprises all of the cadmium colors from the palest yellow to the deepest orange. All of the cadmium colors are manufactured by precipitating a salt of cadmium with a salt containing a sulphide, so that the cadmiums are sulphides of cadmium, and according to the speed of precipitation, temperature of the solutions, admixture of acids or alkalies, all shades from brilliant yellow to the deepest orange are formed.

All writers practically agree in stating, and the experiments of the author confirm it, that cadmium yellow may be regarded as a perfectly permanent pigment. The artistic painter is fortunate in having such a brilliant color at his command. Much has been written on the supposed reactions that take place between this and other pigments. It is said, though being a sulphide, it should not be mixed with a lead color, because the sulphur in the cadmium would combine with the lead with a blackening effect. Ordinarily, this is not so. Cadmium sulphide is a very stable chemical compound, and will not give up its sulphur as readily as artificial ultramarine blue will; for instance, there should therefore be no hesitancy in using cadmium sulphide with any lead compound, although, to make assurance doubly sure, zinc white could be used as when a cadmium color is mixed with zinc there can not possibly be any visible effect of decomposition.

It is unfortunate, perhaps, that cadmium sulphide is so very expensive. The dry pigment itself costs at this writing about $3.00 a pound to manufacture, but no artistic painter should be without this yellow, and above all it should only be bought from a manufacturer of excellent reputation.

Cadmium yellow may fail, and in many instances does fail, because it is improperly made and because it is ground in an emulsion of oil and water, or because the oil in which it is ground may be of a highly acid nature. Manufacturers of tube colors ought to learn the lesson that no tube color should be ground in a chemically bleached vegetable oil, for oils are principally bleached by means of a strong acid like sulphuric or chromic, and all traces of these acids are not entirely washed out, so that much trouble may arise from the ultimate effect of this trace of acid, and even a good color like cadmium may be decomposed if the oil be not entirely pure.

The cadmiums are slow but reliable driers and may be mixed with all other chemical pigments, even flake white, without decomposing.

## CALEDONIAN BROWN

Caledonian brown may be a mixture of brown umber and raw sienna in varying degrees, or it may be a mixture of vandyke brown and sienna. In the latter case it would not be permanent. In the former case it would be, and in all events, no two manufacturers use the same mixture of pigments nor obtain the same shades, and as the painter can obtain the shade he wants by mixtures of these permanent pigments, there is really no reason why this color should be added to the already complicated list of painters' tube colors. It has a tendency to grow darker upon very long exposure, and when it contains manganese is a good, hard drier, but when it contains large quantities of vandyke, it is a soft, slow drier. It is easily produced on the palette by mixing sienna and umber.

## CAPPAH BROWN

Cappah brown is a species of decomposed bog earth similar in composition to a mixture of vandyke brown and burnt umber. It is similar to umber on account of the manganese which it contains, and therefore is a good drier. It is, however, not very stable in bright sunlight and darkens somewhat on exposure owing to its content of bitumen. It can easily be spared from the list of browns.

## CARBON BLACK

This is an extremely fine pigment stronger than lamp black and intensely black, in fact, in blackness it compares favorably with ivory black. It is permanent, and does not affect any other pigment with which it may be mixed. Its great strength (tinctorial power) can be shown very easily as follows: if one takes one part of carbon black and twenty parts of permanent white and mixes them together, the result will be a black which will approximate the shade of lamp black. In other words, it has such intense coloring properties that it stains every other color with which it may be mixed. Although it is absolutely harmless under all circumstances, it is no better than ivory black and possesses a number of disadvantages. It is an extremely poor drier and retards the drying of every other pigment with which it may be mixed, so that ivory or bone black should be used in place of it.

## CARMINE

Carmine is the coloring matter of the cochineal bug which is mordanted or fastened by means of alum. It is an intensely brilliant red, translucent and works well and dries fairly well, but it is exceedingly fugitive, and is not only bleached by the action of sunlight, but is destroyed by many of the metallic pigments. There is no effect that can be produced with carmine that cannot be produced with the madder lakes, and therefore carmine should never be used on any painter's palette.

### CARMINE LAKE

Carmine lake is a deep maroon which is made after the first coloring matter is extracted from the cochineal bug. It may have a pleasing maroon shade, and it may have good working qualities, but in six days in the bright sunlight it shows a loss of brilliancy and begins to fade. This quality should eliminate it as a pigment for artistic use. It is decomposed in the presence of the ochres.

### CARNATION LAKE

Prior to 25 years ago this lake was a carmine derivative. Within the last 20 years the author has found a carmine sold under the name of carnation lake which was evidently a wood extract and fugitive, and another sample which was a reduced form of madder lake. The former was fugitive and useless. The latter, while not very brilliant, was permanent, so that, at this writing, it is impossible to say whether carnation lake, as a general statement, is permanent or not, for it depends entirely upon the maker. Under the circumstance it is advisable not to use it for it is not essential, as the same shade is sold under the name of scarlet madder.

## CASSEL EARTH

This pigment may have been in former years an ochrey brown, but at present it appears to be identical with vandyke brown, and is not regarded as a permanent color. It will be properly described under the name of vandyke brown.

## CERULEAN BLUE

In the present age cerulean blue is an artificial ultramarine blue of pale shade known commercially under the name of artificial cobalt blue. Some manufacturers in order to give it its proper tone grind this pale commercial ultramarine blue with a mixture of zinc oxide, and it has the property of appearing blue under gas light or electric light. The author finds that when made by reputable concerns, it is perfectly permanent and can be mixed with almost any pigment excepting those containing lead. Its existence complicates matters, however, for the ordinary cobalt blue of commerce mixed with white will produce practically the same shade and effect.

## CHARCOAL GRAY

This pigment appears to be a vine black reduced with permanent white. When badly washed in its original manufacture it has a tendency to become hard in the tubes. It can easily be substituted by mixing lamp black with permanent white, and although it is a permanent color and not affected by any other color, it is a hard drier, owing to its alkaline nature, and if used on top of a soft drying color like any one of the lakes, it would show a tendency to crack.

## CHINESE BLUE

This is a ferrocyanide of iron sold also under the name of Prussian blue, milori blue, steel blue, bronze blue, Antwerp blue and various other names. It differs from Prussian blue physically only in the fact that when mixed with white it produces a clear sky-blue tint. Chemically it is unstable, for, when mixed with white lead and allowed to remain on the palette over night it will be blue where it comes in contact with the air, and decomposes into a pale, sickly green underneath the surface. It does not show this defect when mixed with permanent white or zinc oxide. If mixed with one of the charcoal or vine blacks which contain a slight amount of alkali, it loses its color and becomes brownish, but when properly made and thoroughly washed in its original manufacture and used alone, it is practically permanent. It may have some excellent working qualities, and may be a beautiful, rich color, but all its shades and delicate effects can be reproduced by means of more permanent blues. Therefore, there is no reason why this blue should be used.

## CHINESE VERMILION

Chinese vermilion is one of the oldest pigments known to artistic painters. The reader is referred to the chapter on synopia for a history of the use of this pigment. Whether the ancient Greeks and Romans obtained vermilion from China or the Idria section, it is difficult to say, but the chances are that the Oriental travelers brought some of the native vermilion with them in addition to that which was found in Europe.

Vermilion is a sulphide of mercury, and is artificially made by mixing sulphur and mercury in the presence of an alkaline solution under heat and pressure. It ranges in shade from a light orange to a deep scarlet, and while it is perfectly true that when used alone as an oil color and exposed to the brilliant sun rays, it will darken considerably, when glazed over with madder, as is frequently done after it is thoroughly dry, it is remarkably permanent, or when properly varnished it is very stable. It is a good drier and has great opacity.

## CHINESE WHITE

Chinese white is a zinc oxide. Its name would imply that it is a color invented by the Chinese or found in China, neither of which is the case. It was invented in France, and probably to hide its origin some manufacturer called it Chinese white. The description will be found under the head of zinc white.

### CHROME GREEN, LIGHT, MEDIUM AND DARK

These greens are unfortunately named, because although there is some chromium in their composition from the chromate of lead which they contain, they are strictly speaking, not pure chrome greens, such as guignet or viridian green. Chrome greens are essentially a double precipitate of chrome yellow and Prussian blue, and vary in shade according to the percentage of yellow or blue which they may contain. These colors may work very well and dry very well, but have the combined defects of chrome yellow and Prussian blue. Assuming that the color is properly made, it is fairly permanent to light, has tremendous tinting power, but is acted upon by sulphureted hydrogen, and even when not subjected to the action of any gas, it loses its brilliancy within a very few years. It is not recommended as a necessary color and can be very well omitted.

### CHROME ORANGE AND CHROME RED

Both of these colors are chromates of lead made with the addition of lime and are not any more permanent than the other shades of chrome yellow. In chemical composition they are equal to chrome yellow mixed with a small percentage of red lead or orange mineral. In view of the fact that cadmium orange exists and is much more permanent, chrome orange should be eliminated from the palette.

**CHROMIUM OXIDE (See French Veronese Green)**

### CINNABAR GREEN

The word cinnabar refers entirely to the sulphide of mercury, and when chrome green was first made, some manufacturer called his product cinnabar green, intending to convey the idea that his mixture of chrome yellow and Prussian blue was as permanent as cinnabar red or native vermilion. The name has stuck to it in the trade. An examination of the pigments shows that it is by no means a pure chrome yellow and Prussian blue, but is reduced with either whiting, permanent white or other reinforcing pigment, and owing to this reduction it is more permanent than the concentrated color, because it does not contain as much pigment that can spoil or deteriorate as the concentrated color does. In brilliancy, tone and strength, it is quite satisfactory, but it is not permanent and is easily affected by noxious gases.

### CITRON YELLOW

Citron yellow is also known under the name of primrose yellow, and is usually composed of a mixture of chromate and oxide of zinc. Inasmuch as this color is somewhat soluble in water, it cannot be very thoroughly washed, and in the presence of moisture has a marked effect on almost every color with which it may be mixed. When used alone, it is quite permanent and not affected by noxious gases of any kind, and when varnished before it has any opportunity for decomposition, it is remarkably permanent. In former years it was regarded as a fugitive color, but this was due to defects in its manufacture. Now the color has a fairly large sale for coach painting, but as an artists' color there is no reason to use it, because the pale shades of cadmium mixed with permanent white produce identical effects with no serious results.

## COBALT BLUE

This color is very difficult to describe, as it may be a pale shade of artificial ultramarine blue, or it may be a true oxide of cobalt, or it may be a salt of cobalt mixed with alumina and barium. A tube no larger than your little finger may sell anywhere from 25 to 40 cents, but that is no indication whatever of its quality or composition, and the majority of samples of cobalt blue as sold, that the author has examined, consist of artificial ultramarine blue, and as such are among the most permanent and useful pigments which the artist can possibly use. Owing to the fact that cobalt and its chemical derivatives are expensive, the high price still clings to the cobalt blue which the painter uses, but this is more or less unwarranted, because the artificial cobalt blue (ultramarine) is very inexpensive and exceedingly permanent, except when mixed with another pigment which contains lead, like flake white, white lead, chrome yellow or chrome green. It should also be kept away from colors containing copper, lead and iron, and such metallic bases as are affected by sulphureted hydrogen, for the slightest trace of acid will liberate sulphureted hydrogen from cobalt or ultramarine blue.

On the other hand, it is still possible to buy genuine cobalt blue which is a brilliant blue glaze, finely powdered. The beautiful blues produced on china ware by means of vitrification are generally produced by means of oxide of cobalt, which turns blue at a very high temperature. When these blue glazes are finely powdered whether they be brought up in a medium of glass or of pottery is the same. As such, these blues have very little hiding power, but are exceedingly brilliant and strong and unchangeable. They are used as transparent glazes, but the artificial cobalt blue made from ultramarine is just as transparent, and when used alone just as permanent. At the same time, the minute broken bits of glass of which genuine cobalt blue is composed refract and reflect the light with such brilliancy that the optical value of the color is enhanced.

Cobalt blue is sold under the following names: smalt, powder blue, Vienna blue, royal blue.

### COBALT GREEN

Cobalt green is made in various ways. Some manufacturers mix a pale shade of ultramarine blue which is known commercially as artificial ultramarine green with a mixture of oxide of zinc. Sometimes it is made by grinding oxide of zinc and zaffer which is a native oxide of cobalt. In any case the cobalt green which has been examined is apparently very permanent, but lacks very much in opacity, which, however, is no detriment, because the color is principally used as a glazing color. It appears to be a very expensive color when made from the salt of genuine cobalt, and as such is permanent under any and all conditions. It may also be a composition of genuine cobalt blue mixed with chromate of zinc or zinc yellow, in which case it would also be permanent, but if it is a mixture of ultramarine blue and chromate of zinc, it is not permanent, and has sometimes been known to decompose in the tube.

It is difficult for the painter to tell what the composition of cobalt green may be, but inasmuch as genuine chrome green which is described under the name of viridian and oxide of chromium is more permanent and of practically the same shade, the use of cobalt green may be eliminated.

### COBALT VIOLET

This is also a chemical precipitate made with phosphate of cobalt, and has evidently been used for nearly a century. It is exceedingly permanent and translucent, but has not the tinctorial power of the purple madders which easily replace it.

There is a violet ultramarine which is sometimes sold under the name of cobalt violet. This color is a beautiful, clear, transparent, permanent color. When used alone or as a glaze over any other dried color, it dries slowly.

### COLOGNE EARTH

This may be a native vandyke brown tinted with lamp black, or a native vandyke brown which is calcined so that the organic matter chars and blackens. It dries somewhat better than vandyke brown, is fairly permanent, but not quite as translucent, and is analogous to cassel earth and Rubens brown. If the glazing color which David Teniers, the younger, is supposed to have used, was cologne earth, we have no reason to doubt its permanency, and all experiments made by the author show that it can be freely mixed with other pigments without producing any decomposing effect.

### CONSTANT WHITE

There is no question that this material which is an artificial sulphate of barium is one of the most useful pigments for indiscriminate use. It is quite true that it lacks opacity, and that even when piled on thickly shows a transparency which for many purposes is detrimental from the artistic and technical standpoint, but due consideration must be given to the fact that it is a valuable pigment which can be indiscriminately mixed with every pigment that is permanent without producing any harmful effect. For producing a permanent glaze, and substituting bitumen, which is easily decomposed, permanent white can be mixed with any one of the solid colors, and the same effect produced. It is not affected by any gases, and when scientifically prepared, has little or no action on the oil. In other words, there is no tendency to turn the oil yellow when placed in the dark. This material is also sold under the name of blanc fixe, and although some manufacturers produce a permanent white which is largely composed of zinc oxide, there are others who grind the dry blanc fixe in oil, and still others who mix dry blanc fixe with zinc oxide. There are many lake colors which are precipitated on this material, and therefore a quasi lake can always be made by the painter by taking a small proportion of the solid pigment and mixing it with a large proportion of constant white. It dries well and is very reliable.

## COPAL MEGILP

When linseed oil is boiled with oxide of lead and manganese to a temperature of above 500° F., a chemical decomposition takes place, and the metallic compounds are dissolved in the linseed oil. Strictly speaking, in the chemical sense, a linseed oil metallic soap is formed which is frequently used as a drier, and under some circumstances is reliable, but under others is not. For instance, as when megilp is mixed with any one of the blacks, such as lamp black, carbon black, ivory black, gray black, etc., it hastens their drying, but should not be used with the colors which naturally dry well. When megilp is mixed with the chemical colors, a change in shade almost invariably takes place, and it is an established fact that after megilp is dry to the touch, it keeps on drying until the resulting film is hard, brittle and contractile.

Where megilp is used indiscriminately, a picture is almost invariably likely to crack, and even though it may have some good qualities, its bad qualities so far outweigh them that it should not be used for permanent painting.

### CORK BLACK

This is a carbon black produced by calcining cork. It is grayish in color but has extreme strength. It is a very slow drier, which is characteristic of all carbons. It is very permanent but has no advantage over lamp black.

### CREMNITZ WHITE, CREMS OR KREMS WHITE

In all respects this white is similar in chemical composition to flake white or white lead. It is chemically produced by what is known as the "quick process," and is made directly from a solution of acetate of lead. It is exceedingly heavy, but crystalline in structure, and very easily affected by sulphureted hydrogen. It should not be used in painting portraits because zinc white is far more permanent. However, it has one good feature and is useful for one purpose. In preparing a canvas cremnitz white mixed with turpentine produces a flat ground which has what the painter calls "tooth." The surface has a fine grain, to which subsequent colors adhere well, and as such its use is permissible.

### CRIMSON LAKE

This is a beautiful shade of cochineal lake, and is manufactured from the coloring matter which remains after the carmine has been precipitated or extracted from the cochineal bug. It is, however, a useless color. It not only dries badly, but when submitted to the sunlight for 10 days, it bleaches badly. It should never be used under any circumstances for permanent painting, and is similar to carmine lake.

### CRIMSON MADDER

This is a form of madder lake manufactured very largely from alizarin, which is chemically the same as the madder produced from the root. It is very permanent as long as it is used alone or when used as a glaze over a thoroughly dry surface, but when mixed with any one of the chemical colors, or the native earth colors, it decomposes rapidly, and therefore should not be used indiscriminately. It dries slowly.

### DAVEY'S GRAY

Davey's gray is a permanent color which is prepared from a silicious earth, either clay or slate, tinted with artificial cobalt. It is not used in America to any great extent, because it is assumed that the color may be produced by a mixture of constant white, lamp black and cobalt blue. It is permanent and has no effect on other colors, but is affected by sulphureted hydrogen, or when made with artificial ultramarine blue decomposes lead colors.

### DEEP MADDER

This is a permanent glazing color when used alone or when glazed over other colors which are dry. In shade it approaches carmine lake and should be used in the place of carmine lake. It dries very slowly, but can be generally recommended as a safe pigment. Must not be mixed with ochre, lead or native earth pigments.

### EMERALD GREEN

There is apparently no green which is as brilliant as emerald green. It is also known under the name of

Paris green or emeraude green. It is a peculiarly crystalline color, and when ground exceedingly fine loses its brilliancy. Some samples contain green aniline, which is added for the purpose of giving it staining power, because emerald green of itself is a defective and exceedingly weak color. Being a compound of arsenic and copper, it is very easily decomposed by sulphur gases, although it is fairly permanent to light. It is one of the fugitive colors for whose existence there may be some excuse, because it is exceedingly brilliant, and when used with extreme care and varnished over as soon as it is thoroughly dry, there is no reason why it should not last 50 or 100 years.

Marine painters use it for painting the starboard light, and sometimes produce a most brilliant effect by starting with a hydrated oxide of chromium, then painting a ring of emerald green, and in the center placing a touch of zinc white. This gives the effect of luminosity.

Emerald green dries slowly and should always be used alone. It sometimes destroys lake colors in a few hours.

### EXTRACT OF VERMILION

This is a misnomer, for there is no such thing as an extract of vermilion. The color is generally a very pale vermilion of scarlet shade, and the description under the head of Chinese and English vermilion answers the description of extract of vermilion.

## FIELD'S ORANGE VERMILION

This color is composed of the sulphide of mercury, the same as extract of vermilion, Chinese vermilion, etc., and differs only in shade, being somewhat deeper than cadmium orange or orange chrome yellow. It is regarded as permanent when used alone and is a fairly good drier.

## FLAKE WHITE

The Dutch were the first to manufacture white lead, by what is known as the Dutch process, which consisted in submitting sheets of lead to the heat of decomposing manure and the vapors of vinegar. They found that the metallic lead was decomposed after 3 or 4 months, and flakes of white replaced the metallic lead. The Dutch called this pigment scheel white, which means scale or flake, and when we use the term "flake white" we always refer to white lead.

There is no question that flake white has certain defects, its principal one being that it is affected by sulphur gases. Another defect, which it has in conjunction with many other pigments, is its tendency to turn a painting yellow. Much of the yellowness of age is due to the decomposition which takes place between flake white and the oil or varnish used as a medium.

At the same time, there are many pictures which are hundreds of years old in which the flake white has been rejuvenated even after it has turned brown or yellow through the effect of gases. From a mechanical standpoint flake white is an unctious paint which works very well under the artist's brush, and when properly dry and glazed over with zinc, cannot be considered as fugitive or easily decomposed. It has the advantage over zinc, that it does not dry continuously, nor does it become exceedingly brittle with age, but zinc has so far replaced it that there is really no reason why it should be promiscuously used.

### FRENCH BLUE

This is an artificial ultramarine blue which is absoluely permanent to light, dries fairly well, and can either be used as a glaze or as a solid color. It must never be mixed with flake white, chrome yellow, chrome green, emerald green, or any pigment containing a metallic base, excepting zinc. When mixed with zinc, any re-action that may take place is not visible or apparent, and for this reason is one of the most remarkable colors that we have. It is identical in composition with the genuine lapis lazuli or natural ultramarine blue, and the author cannot find that it is inferior in any respects to the natural stone.

It contains a large amount of sulphur, which is very easily liberated in the presence of an acid, and in view of the fact that there is free acid in the atmosphere in any city, it is well to bear in mind that this pigment should never be mixed with any other pigment which the free sulphurous acid is likely to decompose. In the chapter on drying oils evidence will be adduced which will demonstrate that decomposition can take place only in the presence of water or moisture, so that the decomposition of ultramarine blue by acid with flake white can be prevented.

### FRENCH ULTRAMARINE

The same as French blue or artificial ultramarine blue. It was first made in France but to-day Germany and the United States are the largest producers of ultramarine blue. When used alone or when mixed with zinc white it is absolutely permanent. There are no less than twenty shades of French ultramarine ranging from the palest cobalt to the deepest ultramarine. Other varieties are also made, such as green, violet, purple and red, which will be described in their proper places.

### FRENCH VERMILION

The same as Chinese or English vermilion.

### FRENCH VERONESE GREEN

French Veronese green is now a permanent pigment which does not possess very much opacity, but can be readily mixed with any other pigment without any injurious effects. There is a story extant that Paul Veronese was the discoverer or inventor of this color, but it is doubtful whether this is true, in view of the fact that the production of hydrated oxide of chromium was evidently not known during the time that he lived. The true Veronese green named for him was more likely a clay colored with hydrated oxide of iron known to this day under the name of terre verte or green earth, although from the evidence which we have at hand, terre verte was used long before Paul Veronese was born.

Veronese green is similar to the genuine chrome green, of which there are two kinds, the solid or opaque kind, known under the name of chromium oxide, and the transparent kind, known under the name of viridian. Viridian is sometimes known under the name of guignet green, but it is generally believed that guignet green is the oxide of chromium and not the hydrated oxide.

It must be borne in mind that the hydrated oxide is a transparent color similar to a lake, and the oxide of chromium is an opaque pigment with intense hiding power. Both the oxide and the hydrated oxide are very permanent under any and all conditions, and can be mixed with other pigments with the exception that the hydrated oxide and madder lake show some slight decomposition, but as has been properly pointed out, there is seldom, if any, opportunity, where madder lake must be mixed with oxide of chromium to produce any given shade.

Veronese green is a good drier and a reliable color.

## FOUNDATION WHITE

This is the ordinary white lead of commerce which is generally a very pure article, and is identical with that which the house painter uses. As such, it is not by any means the best foundation white, and cannot compare with a mixture of zinc oxide and white lead. For foundation purposes, such a mixture dries very well, and produces a surface which is neither too hard nor too soft, and after it has dried sufficiently hard, presents a surface to which other pigments adhere very well. Such a surface has what is technically known as "tooth," so that when we speak of a pigment having "tooth," we refer to a physical surface to which other colors adhere properly.

Foundation white may be made by the painter of a mixture of ordinary house painters' pigments, such as zinc white and white lead ground in linseed oil. It should be thinned only with turpentine so as to dry with a gloss. A little picture varnish (mastic dissolved in turpentine or damar varnish) may be mixed to give elasticity but as these varnishes become brittle in time, fat oil (a fatty linseed oil) is preferable and a small quantity in foundation white is to be recommended.

### GALL STONE OR EXTRACT OF GALL

This is a true organic color with which the bile of the gall bladder is strongly tinted. When this bile is combined with lime and magnesia, it forms small nodules known as gall stones. It has its origin during the time when the ancients used almost any material which had tinctorial power, but as it possesses no particular merit and is exceedingly fugitive, it is not to be recommended for painting.

### GAMBOGE

Gamboge is a semi-soluble resin which is obtained from a particular tree in India, Ceylon and Siam. It is a coloring matter which has many of the characteristics of the yellow coloring matter in linseed oil, in fact, a chemical examination of it indicates that it is analogous to xantophyll and is not as fugitive as the yellow coloring matter obtained from turmeric, Persian berry, etc. We find it on the market in combination with alumina as a base, and as it has no hiding power whatever, it must be regarded as a stain or a true lake, for it is quite transparent. It is seldom sold in its pure state, and as an oil color, the dye which gamboge contains is mordanted on alumina as a base. It bleaches somewhat when exposed to strong sunlight but recovers its color again when placed in the dark, which is characteristic of the coloring matter of many of the vegetable oils. It is of a true resinous nature, and therefore acts like a varnish gum, for it dries with a considerable gloss. It is not very stable, and while it may dry fairly well by itself, it acts similar to bitumen, retarding the drying of other colors. It is therefore not to be generally recommended.

### GERANIUM LAKE

It is very unfortunate that in the early 70's when the dye known as eosine was invented, many brilliant lakes were made for the painter, which exceeded in strength and effectivenss any coloring matter that had been known before that time. There are two shades of geranium, the bluish and the yellowish, both of them exceedingly brilliant, some of which are precipitated on alumina and some on minium or red lead. In any case, geranium lake is so fugitive when made of eosine, that in 24 hours it begins to bleach, and many a painter has had his work completely destroyed by the use of pigments of this class. It is unfortunate that these colors were ever sold to painters. They should under no circumstances be used. The madder lakes easily replace geranium lake and should be used instead.

### GERANIUM MADDER

When this pigment is made of a very bright form of madder it is safe to use it as a glazing color, as it is perfectly permanent. It is like all the madders which are easier to use as glazes than in mixtures with any pigments which may have an ultimate effect, that is, the color will change in time. It dries very slowly and must not be mixed with ochre, raw sienna or flake white.

### GOLD OCHRE OR GOLDEN OCHRE

Ordinarily this pigment is French ochre toned with chrome yellow, and the painter should not use it, for it is far preferable to use ordinary ochre, toning it, if necessary, with cadmium yellow. All the ochres have a slight tendency to darken upon exposure. They must not be mixed with any of the lake colors, but when mixed with any of the mineral colors are practically permanent. Ochres all dry very well and when once dry are permanent.

### GREEN LAKE

This pigment is prepared in various ways, and is generally conceded to be a fugitive color which has little or no value. When made of an aniline dye precipitated on alumina it will fade within a week, but when made of zinc yellow and Prussian blue diluted with alumina, it will retain its brilliancy for many years. There is another variety on the market which is made of Dutch pink or quercitron bark extract and Prussian blue, which is not as permanent as that made from zinc yellow. The color is not to be recommended.

## HARRISON RED

This is a new pigment of the aniline series which is exceedingly brilliant and probably ten times as strong as quick silver vermilion. In shade it approximates a mixture of light and dark English vermilion, but in tinctorial power it is remarkably strong. It is much more permanent to light than vermilion, and like vermilion it has a tendency to darken and not to fade.

Its composition is similar to a proprietary red known as helio fast red, and is made by one of the large aniline manufacturers in Germany and they probably named it in honor of the American artist, Birge Harrison.

This pigment possesses some analogies to the paranitraniline colors, but has the advantage of not bleeding. In other words, after it is dry, and when white is painted over it the red does not bleed through and turn the white into a brown as is the case with para reds.

Harrison red may be said to be permanent when thoroughly diluted with alumina lake and white; it does show slight traces of decomposition after three months' exposure to the sun, but not sufficient to condemn it, and it may be said that the only disadvantage concerning this color, known at present, is its inability to dry. When Harrison red is mixed with oil it sometimes remains absolutely moist and smeary for six or seven weeks, which, of course, is a serious disadvantage. At the same time the addition of a drier or a drying oil changes the brilliancy of its shade, so that it might be well in the use of this color to reduce it only with turpentine and then expose it to the light. It mixes well with madder lake without showing very much decomposition.

### HOOKER'S GREEN

This pigment is similar to the green lakes just described, with the exception that it has some hiding power. Some manufacturers, in order to make it more permanent, use a mixture of orange chrome yellow, Prussian blue and alumina, which is not as brilliant as the pigment made from yellow lake or gamboge, but it is much more permanent.

One sample examined by the author appeared to be a mixture of Prussian blue and raw sienna. Such a mixture is permanent and dries well.

### INDIAN BLUE (See also Indigo)

This color is obtained from the leaves of certain plants which are found principally in India. Within the last few years it has been made the subject of research, as in the case of madder, so that it is now manufactured artificially from coal tar. The pigment present in artificial indigo is identical with that in the natural, but the artificial color is purer. In its over-tone it is similar to Prussian blue, but is much weaker, and somewhat transparent, having all of the characteristics of a lake color. It dries poorly, and when a manganese or lead drier is added to it it is quickly decomposed. When it is exposed to the sunlight it fades rapidly. It is, therefore, useless for artistic painting.

### INDIAN LAKE

Indian lake is a deep red lake which is assumed to be the lake that exudes from the tree from which gum shellac is recovered, and is one of the lakes which was probably used by Sir Joshua Reynolds, which tended to destroy his pictures to such a great extent. In permanency it is better than carmine, and not by any means as good as madder, and like all organic lakes is quickly decomposed when mixed with some of the iron oxide colors. It is fugitive and unreliable, dries very badly and should not be used.

### INDIAN PURPLE

Indian purple is a complex mixture originally made by taking a weak form of Prussian blue and mixing it with vermilion. As such, it was very deep toned and muddy, but was fairly permanent. Later on, carmine was added to this mixture, but it was found that, although the brilliancy of the colors was enhanced, it was less permanent than before. Nowadays it is made by coloring or mixing ultramarine blue with madder lake, during the process of manufacture of the madder, and is regarded as a fairly permanent color. It can be readily duplicated on the palette.

### INDIAN RED

This is a true oxide of iron which contains no water in its combination, is extremely permanent, and can be generally recommended when it is unsophisticated. Unfortunately a number of manufacturers of artist tube colors spoil this good and permanent color by adding a lake in order to enhance its brilliancy, and in doing so destroy the permanent value of the pigment. The name Indian red is supposed to have originated from two sources; the first, because a native form of hematite or red oxide of iron which contains silica was found, and is still found, in the Orient, particularly in Persia, and, in the second place, from the further fact that the North American Indians used the native red ochre or hematite as a wash for the wigwams, and as a coloring matter for personal decoration. In either case, the colors chemically are the same and are bright red oxides of iron. Much of the Indian red, however, which is used by color makers, is artificially prepared by burning copperas (sulphate of iron), until the acid is entirely driven off, and only the oxide remains. When this is washed it forms a bright red, solid color which can be mixed with nearly every other permanent pigment, and may be regarded as fairly permanent, with one or two exceptions. Upon long and extreme exposure the bright Indian red loses its brilliancy and turns darker, which is due to the chemical change or decomposition from the ferric to the ferrous state. The ferrous oxide of iron is a black oxide with which the artistic painter is not acquainted. The ferric oxide of iron is the bright, red oxide. The darkening effect of Indian red is due to the slight change from the ferric to the ferrous oxide. The same is true when Indian red is mixed with zinc oxide to produce a flesh tint. The author exposed a sample so made for three years to the bright daylight, and at the end of three years a very slight darkening effect had taken place, but inasmuch as artistic paintings are rarely, if ever, exposed to the bright sunshine throughout the entire year, Indian red must be regarded as one of the permanent and reliable pigments.

Indian red dries very well and has enormous hiding power (opacity). When mixed with zinc oxide to produce a ground for flesh tints it is very reliable. There are many shades of Indian red. Some produce a violet when mixed with white and others a distinct pink or rouge. All are permanent when pure. When Indian red is toned with madder lake it is frequently called tuscan red or Pompeian red. Indian red does not decompose madder lake.

## INDIAN YELLOW

This color is similar in many of its characteristics to gall stone yellow, and inasmuch as it is made from the excrement of camels, its coloring matter is somewhat similar to the biliary coloring matter, and while it is brilliant and transparent, it is just as fugitive as gall stone yellow, and is not to be recommended. It dries badly.

## INDIGO

This is a color extracted from the indigo plant which grows in the East Indies, and has been in use for many centuries. It is used both as an oil color and a water color but possesses no particular advantage. As an oil color indigo dries very slowly, fades when exposed to light, is destroyed or reduced when mixed with chrome yellow, white lead and the majority of metallic paints. It can be safely substituted by a mixture of Prussian blue and lamp black, or better still, by a mixture of Antwerp blue and lamp black, Antwerp blue being a reduced form of Prussian blue. It is of doubtful value, and it is a question whether any of the old painters used it to any great extent. While it is accepted that it makes a very desirable green when mixed with raw sienna or a yellow lake, it is not as good as a mixture of Prussian blue and raw sienna, and as yellow lake in almost any form is fugitive the resulting color is not to be recommended.

Indigo should therefore be excluded from the palette.

## ITALIAN PINK

This is the same as Dutch pink or yellow lake, its name is a misnomer, because it is a transparent olive yellow, and not a paint. It is quite fugitive. It dries very poorly and should not be used.

## IVORY BLACK

Ivory black is prepared from charred ivory, and contains only about 20% of carbon black, the balance of it being phosphate of lime or bone material, but it is unlike any other black, on account of its intensity. In fact, it is so black by comparison, that on an ivory black ground a stripe of lamp black is distinctly discernible, or visa versa, a stripe of ivory black will make a black mark on lamp black. It is perfectly permanent and dries very well, and can be mixed indiscriminately with any other permanent color.

## JAUNE BRILLIANT

This is also known under the name of brilliant yellow, its name being a translation from the French. It is made in two ways, the one producing a permanent and the other an unreliable pigment. The permanent brilliant yellow is made of zinc yellow mixed with zinc oxide to give it hiding power, and is a brilliant, permanent color. By the other method one part chemically pure lemon chrome yellow is mixed with twenty parts of white lead. The latter is stronger and has more hiding power than the former, but is easily affected by sulphureted hydrogen, and is not as permanent as the zinc yellow. It dries very well and should be used alone.

## JACQUEMINOT MADDER

This is merely a bluish shade of madder, very strong, brilliant and permanent, and ranks with all the other madder lakes. It dries very slowly and for flower painting is absolutely permanent when used as a glaze over a dry ground. It is frequently mixed with ivory black to produce a brown lake.

## KING'S YELLOW

This is prepared in several ways. Some manufacturers make it similar to the formulas of brilliant yellow just described. Others mix chrome yellow and flake white. Formerly, it was made by grinding the mineral orpiment, which is a sulphide of arsenic, and has been used as a pigment for several thousand years. When used absolutely alone, it has some qualities which may recommend it, but it is almost impossible to use a pigment of this kind alone, for the mere addition of a small amount of drier is sufficient to destroy the brilliancy of orpiment, hence manufacturers have been led to make it by using zinc yellow or chrome yellow as a base. In any case, orpiment is useless and not to be recommended, as King's yellow has all the characteristics of brilliant yellow with which it is analogous.

### LAMP BLACK

This pigment is now made by condensing the smoke of various burning coal tar oils. It is almost a pure form of carbon, is intensely strong, and differs from carbon black and ivory black in that it produces a distinctly bluish gray shade when mixed with white. It is a very bad drier, and remains very flexible for a long time. Therefore, it is always advisable, when a gray is to be made, that zinc oxide and lamp black be used, because the flexibility of lamp black overcomes the brittleness of zinc. Lamp black can be mixed with any other pigment. It is not chemically acted upon, nor is it acted upon by light. It can be mixed with any pigment and is absolutely inert. When it refuses to dry it may be exposed to the sunlight and fresh air, which hastens the drying very considerably. Lamp black, however, may be mixed with drier without any harm, but sunlight and air are more reliable.

### LEITCH'S BLUE

This is similar in some respects to artificial ultramarine blue, but not as permanent. It is made by mixing artificial ultramarine blue and Prussian blue. An old variety was made by mixing genuine cobalt blue and Prussian blue. In either case it bleaches slightly, and is not as reliable as either cobalt blue or ultramarine alone. It dries better than ultramarine and can be produced on the palette. It has a tendency to turn slightly greenish in the dark but revives on exposure to light.

## LEMON YELLOW

This may be either chromate of barium or a chromate of strontium, and has many of the characteristics of a brilliant yellow lake, and at the same time is much more permanent than any organic color. It can be mixed with almost every color, excepting those containing hydrated oxide of iron, such as siennas or ochres, and where a yellow lake is desired of exceptional brilliancy, a mixture of constant white and lemon yellow produces very desirable results. It is similar in many respects to chromate of zinc, and may be regarded as a reliable, permanent color. It cannot supplant zinc yellow and may therefore be omitted.

## LIGHT RED

The author finds that some of the light reds on the market are evidently brilliant shades of Indian red, and almost pure oxide of iron. Others are mixtures of burnt sienna and oxide of iron, and still others are forms of burnt ochre, which are oxides of iron and clay. In any case, any one of these three colors are perfectly permanent and reliable, and the description for Indian red would hold good for light red. All of the light reds are good driers, and we find that from the earliest days of decoration as practiced by the Egyptians down to the present day, light red has been used by all painters. When mixed with zinc white or flake white the tendency for light red is to darken slightly and become brownish, but this is not perceptible for many years, and only occurs upon extreme exposure. It is a very reliable pigment.

## MADDER CARMINE, MADDER CARMINE EXTRA AND MADDER LAKE

These are lakes prepared from the madder root that differ somewhat as to shade and brilliancy. They are all similar in composition to the alizarins, and are all permanent, except when mixed with the ochre and sienna pigments, white lead, chrome yellow, chrome green and metallic pigments of that nature. The madder lakes should only be used as glazes, and can very safely be mixed with constant white to produce brilliant and more roseate shades. They all dry slowly and when they "sadden" they can be revived by placing them in the sunlight for a few hours.

## MAGENTA

Magenta is one of the newer, aniline pigments, precipitated on an alumina base, and while extremely brilliant when freshly applied, has absolutely no value whatever as an artistic color. In one week, magenta bleaches perceptibly, and is very easily affected by any of the inorganic pigments. It is not to be recommended and should not be used.

## MALACHITE GREEN: ALSO KNOWN UNDER THE NAME OF MOUNTAIN GREEN

This pigment was known to the Grecians, and is also a semi-precious jewel. It is sometimes found in huge slabs and used in the making of table tops, pedestals and other articles of ornament. It is a brilliant mineral green streaked with a light green, and is a hydrated carbonate of copper. Whether made artificially, or prepared from the green mineral, it has the serious defect that it is affected by sulphur gases, and may either bleach or darken according to the nature of the gas which attacks it, but when properly varnished and used alone, it is quite permanent. In view of the fact that there are other greens which are absolutely permanent, and from which similar shades may be prepared, there is no necessity for the use of malachite green.

This pigment dries well and has been used for over three thousand years. It was well known to the ancient Egyptians.

## MARS COLORS
## BROWN, ORANGE, RED, VIOLET AND YELLOW

### MARS BROWN

This is a natural color, unburnt, and similar in composition to raw umber. It is a very good drier, but must not be mixed with any of the lakes. Of itself, it is a perfectly permanent pigment.

### MARS ORANGE

This has sometimes been called extract of burnt sienna, because it is composed entirely of hydrated oxide of iron which has been properly precipitated and washed. It is very uniform in composition, and identical with ordinary iron rust. It has generally been regarded as a perfectly safe and permanent pigment, but this is not a fact. It attacks not only every lake with which it may be mixed, but is such a hard drier that it has a tendency to crack. It makes most beautiful, clear yellowish tints when mixed with zinc white, and when diluted with constant white, it has every characteristic of a lake, but owing to its chemical composition, it darkens upon extreme exposure, and the beautiful clear tones which it produces when mixed with white have a tendency to sadden upon exposure.

## MARS RED

This is similar in all respects to mars orange, with the exception that it has been heated until the water of combination is driven off, and while it is identical with light red, it is much more transparent. It is a soft, permanent color, and although it is supposed to affect a number of lakes, it is very doubtful whether it does, but in order to practice precaution, it may be wise not to mix it with several of the lakes, but to use the lakes over it as a glazing color. It dries well, and is permanent.

## MARS VIOLET

Mars violet is a very dark form of crocus martis, or Indian red. It is similar to the color known as caput mortum, and is nothing more nor less than a purple oxide of iron. It has a distinctly bluish shade, is very durable, dries well and is permanent to light.

## MARS YELLOW

Mars yellow has also been called extract of ochre, or extract of raw sienna, because it is composed of the coloring matter of these two pigments. It frequently cannot be distinguished from a good quality of raw sienna, is permanent, dries well and is translucent. It has been suggested frequently that mars yellow, or a good form of raw sienna should be used as a substitute for the yellow lakes, and this can easily be done when these colors are mixed with constant white. As a glazing color, it is permanent, but, like all of the oxides of iron which contain water in combination, it must not be mixed with an organic color such as any one of the lakes.

### MAUVE AND MAUVE LAKE

This is a most undesirable though brilliant color, which begins to deteriorate almost the same day that it is applied. It is made from one of the fugitive aniline dyes, but could be made from permanent dyes, although there is no sample on the market which the author has examined that is fit for the artist's palette. In these modern days mauve lake should be replaced by a permanent mauve which would not be difficult to produce, and which would be as permanent as madder, but such a pigment does not exist, to the best of the author's knowledge.

### MEGILP (See Copal Megilp)

### MINERAL GRAY

This is a nondescript color which is made from a solid gray or gang rock, and tinted with the blue ot lapis lazuli. It has very little strength or tinctorial power. Its principal characteristic is its high price. It can very easily be imitated by a mixture of cheaper colors which would be just as permanent. It has, however, no defects. It dries well, is permanent to light, and permanent when mixed with every pigment excepting those containing lead, which it does not affect as quickly as ultramarine blue, because its sulphur content is so extremely low. Zinc white, lamp black and a trace of ultramarine produce the same shade.

### MINIUM

Minium is a very brilliant orange red. It is a pure form of oxide of lead made by calcining flake white. Its shade is similar to that of orange vermilion. It is perfectly permanent to light, but is very susceptible to the action of sulphureted hydrogen. It has the same shade as scarlet quick silver vermilion, and is a powerful drier. It is best to use it alone and it ought to be varnished as soon as possible. When not varnished it bleaches to a straw color on long exposure, which is due to the acid gases in the air.

### MONO CHROME TINTS

These are mixtures of white lead, raw umber, burnt umber, lamp black, ivory black, etc., and on account of the lead content are affected by sulphureted hydrogen, which tends to darken them. When these colors are made on a zinc white base they are much more permanent, in fact, may be regarded as perfectly permanent. They dry well and can be reproduced on the palette.

## MUMMY

Mummy is a form of bitumen or asphaltum used as a glazing color. It was supposed to be permanent, because the bitumen or asphaltum which is found in the mummy cases was assumed to be permanent, because it was so old, and had not undergone any change in its drying condition; but when used as an oil color, it is treacherous, and should not be used for the same reason that no asphaltum or bitumen should be used. It retards the drying of an otherwise good color, and is to be condemned from every point of view.

## NAPLES YELLOW

The old Naples yellow was a mixture of litharge, or oxide of lead and sulphide of antimony, a most unstable color which frequently decomposed itself, but for many years color manufacturers have imitated it by mixing cadmium, yellow, ochre and white, and some manufacturers produce better and more permanent Naples yellow than others. This is due to the fact that this pigment may be a mixture of deep orange cadmium and zinc white, in which case it is exceedingly permanent, but where the zinc white is replaced by white lead or flake white, it is easily affected by sulphureted hydrogen. Except for convenience there is no necessity for having this as a separate color, for the painter can mix up any shade of Naples yellow to suit himself.

### NAPLES YELLOW REDDISH

Naples yellow reddish is the same as any Naples yellow, except that the orange form of cadmium has been used, or a slight tinge or oxide of iron added to the zinc white. Either form of imitation Naples yellow is superior to the natural and is practically permanent, which cannot be said of the genuine.

### NEUTRAL TINT

This is a complex mixture of ultramarine, sienna, lamp black or ochre and lamp black, and under all circumstances is an excellent color which is perfectly permanent. It can be reproduced on the palette and is bought only for convenience. It dries well.

### NEUTRAL ORANGE

Neutral orange is a permanent color also of a complex mixture. It has many of the characteristics of mars orange, but sometimes is made by mixing a brilliant yellow, free from lead, with a bright oxide of iron. When made from cadmium yellow, it is quite expensive, but when made from zinc yellow or barium yellow, it is not quite as strong in hiding power, but is very desirable. The color dries well.

### NEW BLUE

New blue is an artificial ultramarine blue of the cobalt shade, perfectly permanent, excepting when mixed with white lead or flake white, or any other color containing lead. It must not be used in conjunction with a lead drier. By itself it is absolutely permanent and dries well.

### NOTTINGHAM WHITE

This is a form of white lead or flake white, which is described under the heading of flake white.

### OLIVE GREEN

Olive green is a beautiful pigment, composed of a mixture of yellow lake and Prussian blue. It is not permanent and should not be used, for it dries badly and fades.

Olive green may be made of raw sienna and Prussian blue, in which case it dries well and is absolutely permanent, and when mixed with constant white (blanc fixe) or diluted with blanc de lacque (alumina hydrate) produces a lake of any degree of transparency.

Olive green or olive green lake must not be mixed with any other lake.

### OLIVE LAKE

Olive lake is a mixture of ultramarine blue and yellow lake which fades and is unreliable. The mixture described under the paragraph on olive green is to be recommended in its place.

### OLIVE MADDER

Olive madder is a misnomer, there being no true madder lake which is green, but a mixture of ultramarine blue and certain forms of raw sienna or Prussian blue and sienna produce an olive green which is exceedingly permanent, and, although somewhat muddy, can be very safely used, except in the presence of lead pigments. It is a very good drier.

### ORANGE MINERAL (See Minium)

### ORANGE VERMILION (See Vermilion)

### ORANGE MADDER

A scarlet madder mixed with an aniline yellow or a yellow lake like Dutch pink or Italian yellow. This is a most undesirable pigment which remains wet for weeks and in the end, fades. There is, however, no reason why a lake color of an orange shade cannot be made from the para yellows or para reds, but the author has not found any on the market.

### ORIENT MADDER

Orient madder is a deep variety of cadmium yellow, and has all the permanent characteristics of the cadmium series of colors. It is diluted with blanc de laque (alumina hydrate) and has almost as much translucency as a true lake, but dries very slowly.

### ORPIMENT

Orpiment is the same as King's yellow, and was originally a sulphide of arsenic. Some samples of orpiment still found on the market are the arsenic color, and as such are not recommended. The same shade may be produced by mixing various yellows and whites. The true orpiment is not to be recommended.

### OXIDE OF CHROMIUM (See French Veronese Green)

### OXIDE OF CHROMIUM, TRANSPARENT (See French Veronese Green)

### OXFORD OCHRE

This is a muddy grade of ochre found in England, very permanent, and containing more oxide of iron than the French ochre. It is sometimes used as a base for red pigments, and that is done when the ochre is heated to a red heat so that all the water of combination is driven off, and the hydrated iron is changed into a true oxide. It is perfectly permanent, except when mixed with the lakes. When burnt and sold under the name of burnt ochre, it is similar to some of the shades of mars orange.

### PAYNE'S GRAY

Payne's gray is a mixture of black, ochre and blue, and is permanent if the blue used is ultramarine. The water color Payne's gray is a different mixture which is not permanent. It dries slowly.

### PERMANENT BLUE (See Ultramarine Blue)

### PERMANENT GREEN (See Viridian)

### PERMANENT VIOLET

This may be a mineral color composed of phosphate of manganese, and when so prepared is not permanent by any means, and does not deserve the name, or it may be a mixture of cobalt blue and madder lake which is more permanent, but the painter is referred to other violets which can be made from permanent pigments, and should be used in place of the so-called permanent violets.

Violet ultramarine is the most reliable of the violets but should not be mixed with any color excepting, perhaps, constant white (blanc fixe) and zinc white. It is as transparent as a lake, and remains brilliant even in the bright sunlight.

### PERMANENT WHITE

This is a pure zinc oxide described under the chapter on zinc white, dries slowly and is permanent.

### PERMANENT YELLOW

This is a mixture of chromate of barium and zinc white, or chromate of zinc and zinc white. The color is rather weak, but can be safely used with chromium oxide or the viridian colors, and is not affected by sulphur gases or light. Generally it is a very safe color to use, but dries rather slowly. It is also known as canary yellow.

### PINK MADDER

This is a weak variety of madder lake made from alizarin or madder root. It is permanent and safe to use when not mixed with ochre, lead, or any one of the chemical pigments. When used as a glaze over a perfectly dry surface, it is quite permanent, although bright sunlight bleaches it to a very slight extent after the lapse of two years. It is a bad drier, but under no circumstances must it be mixed with a drying oil, because all the drying oils contain metallic substances in solution which act deleteriously on all of the madders. The best way to dry pink madder or any madder lake is to use well settled, old, raw linseed oil, and then expose the picture to the bright light, for the sun will dry madder lake without decomposing it. As this color is largely used as a glaze it is the frequent cause of cracks.

### PRIMROSE AUREOLIN (See Aureolin)

### PRIMROSE YELLOW

This is a pale variety of chromate of zinc, or it may be a mixture of chromate of zinc and chromate of barium, or it may be composed of chromate of zinc and oxide of zinc. In any one of these cases, it is a safe, permanent, reliable color. It dries fairly well, particularly when exposed to light. It is not affected by sulphur gases but cannot be mixed with a lake color.

### PRUSSIAN BLUE

Prussian blue is a chemical compound which is made from the cyanogen obtained from certain organic substances such as leather, horn, feathers, etc. There is a great variety of colors made in this manner, all of which are ferro-cyanides of iron. They are called steel blue, Chinese blue, Milori blue, bronze blue, Prussian blue, Paris blue, Antwerp blue, etc. All of these colors are intensely rich, strong and inimitable, yet the pigment cannot be safely recommended for indiscriminate mixtures. When Prussian blue or any of its analogues are mixed with white lead of flake white, the rich sky blue or greenish tint which will result bleaches over night into a sickly green, but on exposure to the light for an hour, it comes back to its original color. This is a chemical effect known to chemists as "reduction." For certain purposes, Prussian blue is safe and permanent. Several of the ultramarines mixed with black will give a shade or tint which will approximate Prussian blue, but rather than take any chances the painter is advised to avoid the use of Prussian blue, or any color which may be partly composed of this material, excepting for sky effects when mixed with zinc. The so-called chrome greens are Prussian blue mixed with yellow, and although they are strong and brilliant, they lose their brilliancy after some years.

Prussian blue is a good drier, and when used alone is perfectly permanent, provided it is unglazed or painted over a solid ground. When varnished with an oil varnish, or when mixed with megilp or copal, it turns green, but used by itself the author can positively state that in three years it shows no change.

It has very great opacity, and is similar to indigo in appearance. It is far superior to indigo and is a good drier.

The Prussian blues can be safely mixed with zinc and the sienna colors.

### PRUSSIAN BROWN

When Prussian blue is heated, and the cyanogen driven off, it is converted into a form of oxide of iron, which has a rich, deep, chocolate color that is absolutely permanent and perfectly reliable, and is such a stable compound that when mixed with madder lake it does not decompose the madder. It is not only a good drier, but a flexible drier, and after a lapse of many years Prussian brown remains soft and flexible without showing any tendency whatever to crack. It is frequently used mixed with burnt umber, in order to prevent the burnt umber from drying too hard. It is also made by subjecting Prussian blue to ammonia, but this pigment is not as stable as the color made by the hot or burning process.

### PRUSSIAN GREEN

Prussian green is a mixture of yellow lake and Prussian blue, undesirable and unreliable. A better and more permanent Prussian green can be made by mixing raw sienna with Prussian blue.

## PURE SCARLET (See Scarlet)

## PURPLE LAKE

Purple lake is a deep, crimson lake, generally made from the extract of hypernic, which is a variety of wood lake, and is not much more permanent than one of the aniline lakes. It possesses no quality which should recommend it in preference to purple madder, which is very much more permanent.

## PURPLE MADDER

This is a deep variety of madder lake, just as permanent as any one of the madders, but it must not be mixed with a metallic drier, or with any one of the lead pigments or ochres. It is a slow drier, but its drying can be hastened by exposure to sunlight.

## RAW SIENNA

This is one of the safest pigments to use, and works well with every color, except the lake colors. In composition it is similar to ochre, with the exception that it is four times as strong, or in other words, contains four times as much iron, but the iron which it contains is the hydrated form, hence the color is translucent. It is composed of a native earth originally found in and near Sienna, Italy, and was used by the ancient painters. There are a large variety of raw siennas, some of which approach closely a yellow lake. All of them are more or less adapted for the purpose of glazing. Sienna when used in dilute form is almost transparent, and under any circumstances excepting those mentioned, is absolutely permanent with the possible exception that it darkens very slightly after many years. A mixture of raw sienna and white lead or zinc white becomes more mellow in time. It is a good drier.

### RAW UMBER

This pigment is somewhat similar to the raw sienna, with the exception that it contains manganese, and is found not only in Italy but in certain parts of Germany, Cypress and Turkey, and among paint manufacturers the name of Turkey raw umber is applied to practically all the umbers which are found in southern Europe.

It is a translucent color having a peculiar olive brown shade, and cannot be said to be uniform for there are raw umbers which vary in shade from a light yellowish olive to a very deep brownish green. It is a most excellent drier, but has a decomposing effect upon lake colors. It may be very safely used as a glaze, and like the siennas it has a tendency to darken very slightly.

It is a very strong drier and is often used like burnt umber with black to hasten the drying of the black.

It is permanent when used alone and permanent when mixed with blacks, umbers, siennas, ochres and zinc white.

### REMBRANDT'S MADDER AND RUBEN'S MADDER

It is very likely that Rembrandt, Ruben and Franz Hals used madder lake, but Franz Hals evidently was better acquainted with its technical use than any other painter of his time. The brilliant, rubicund flesh tints are almost perfectly preserved to-day, and a minute careful examination reveals the fact that he used madder lake as a glaze only after the under-coats were thoroughly dry.

Why these particular shades of madder should be called Ruben's madder and Rembrandt's madder is merely a question of sentiment, as none of the lakes known under that name differ materially from any other madder lakes. In any case, they are reliable when kept away from the ochre or lead colors, and are perfectly reliable when glazed over the dry colors which otherwise decompose them.

### ROMAN OCHRE

Roman ochre is a native ochre, identical in composition with French ochre or Oxford ochre, and has some of the characteristics of a mixture of ochre and raw sienna. It is stronger in tinting power than the

French ochre, which would indicate that it is a species of sienna, perfectly permanent and reliable, excepting with lakes.

### ROMAN OCHRE, COOL

The description of Roman ochre answers this, only it is a different shade.

### ROMAN SEPIA (See Sepia)

### ROSE DOREE

This is a yellowish shade of madder, and the general description of all the madder lakes applies to this pigment.

### ROSE LAKE

Rose lake is an aniline color, precipitated on alumina, exceedingly brilliant when first applied, but perfectly unreliable and not to be recommended for any painting purposes whatever.

### ROSE MADDER, RUBEN'S MADDER (See Madder Lake)

### SAP GREEN

Originally this was a transparent green lake which was extracted from myrtle leaves, and known under the chemical name of chlorophyll. Whether used as an oil color or a water color, it is thoroughly unreliable, because if it is a green made from the green coloring matter of certain plants, it will turn to a brilliant yellow in the presence of white lead during the process of drying, and will turn dark green again after it is exposed to the air. It is unreliable and not to be recommended. The sap greens sold in tube colors, however, are mixtures of yellow lake, Prussian blue or ultramarine blue, and in any case are not permanent to light and therefore should be excluded. It dries very badly.

### SCARLET RED

When this color is made of a very deep orange chrome yellow, it can easily be detected by its excessive weight. A tube of it lying on the palm of the hand feels as if it were lead. In reality it is a lead color toned with orange mineral. It may be made also entirely of orange mineral, which is a form of red lead and minium. Its principal defect is that it is easily attacked by sulphureted hydrogen. Inasmuch as scarlet red and orange mineral are both identical in shade with orange vermilion, it is much safer to use orange vermilion, although orange mineral or scarlet red, when properly varnished and not mixed with any color, is permanent.

## SCARLET LAKE

This is madder lake mixed with orange mineral, and lately the author has seen samples of scarlet lake which were composed of orange mineral stained with paranitraniline red. Madder scarlet has a slight tendency to bleach, and a para scarlet has a slight tendency to darken. The safest course would therefore be to use any shade of quick silver vermilion, and when dry glaze it with madder.

## SCARLET MADDER (See Madder Lake)

## SCARLET VERMILION (See Orange Vermilion)

## SEPIA

Sepia is either the juice of the cuttle-fish, which this fish uses as a form of natural protection, or is the extract of walnut. The cuttle-fish, when passing through a dangerous zone, obscures the water by ejecting an organic coloring matter, and then hides in this darkened zone. As an oil color, neither of these extracts are of much use, although walnut stain gives a very transparent glaze, but takes so long to dry that it cannot be recommended. Painters, as a rule, mix their own sepia for oil color, one form being a mixture of madder lake and burnt umber, which is very permanent, and another form being carbon black and vandyke brown. However, lampblack, raw sienna and burnt umber make a very permanent sepia which, for glazing, is thoroughly reliable, and which dries very well.

### SILVER WHITE

This is a precipitated white lead. The painter can very well omit this pigment from his palette for zinc white or permanent white could be substituted.

### SKY BLUE

This is a yellowish shade of blue, composed, as a rule, of ultramarine blue very faintly tinted with zinc yellow. It is a very permanent color and dries well. It is easy for the painter to mix his own shades for skies.

### SMALT

This is powdered blue glass, which has been colored with oxide of cobalt. It has, of course, no hiding power, and the principal excuse for its use is the luminous effects which it produces. It is perfectly permanent, and finds its principal use for painting transparencies on glass. When sold as an oil color, in tubes, it is really ground and mixed in a vehicle of gum arabic and glycerine, and unless the painter is familiar with it, it is likely to curl from any oily surface to which it may be applied, and thus defeats the object of its use.

### TERRE ROSE

This is a translucent clay colored with red oxide of iron, and when the red oxide, from which it is made, is thoroughly burnt and washed, it may be regarded as permanent under all conditions. It dries very well and works freely under the brush.

### TERRE VERTE

This is a bluish green transparent color which is a clay tinted with a green hydrated oxide of iron. It has always been regarded as a permanent glazing color, but it is permanent only after it is varnished, but never before. The iron oxide in terre verte is of such a chemical nature that it changes slightly, and this process of decomposition is quite well understood by chemists. It has a disastrous effect upon the lake colors, and therefore it is much safer to use it alone.

### TOUR'S ORANGE MINERAL, OR TOUR'S RED

This is a French oxide of lead made by calcining white lead. It has the brilliant color of orange quick silver vermilion, and is perfectly permanent to light. It is quickly affected by sulphureted hydrogen, and bleaches or pales slightly when subjected to sulphur acids. These defects, however, are not apparent after it is varnished. It is much cheaper than quick silver vermilion, but not as reliable. It is an excellent drier. It is also used as a base for making the vermilion substitutes, because it does not saponify or become hard in the tube. There are a large variety of these substitute vermilions, some of them stained with para red and some stained with madder. The para red vermilions darken in the sunlight, but the madder vermilions are more permanent. As a ground color Tour's red or orange mineral is very reliable.

### TRANSPARENT GOLD OCHRE

This is a species of ochre similar to Roman ochre, and is really a form of raw sienna. The description of raw sienna applies to this pigment.

### TUSCAN RED

When madder lake is precipitated on Indian red as a base and a pigment is formed which has a dull, rose shade that may be regarded as absolutely permanent. There is a painting in the National Gallery of London, by Hubert Van Eyck, of a man with a rose colored cloak, in which the colors evidently used were oxide of iron and madder lake over a white ground. The author finds that some of the Indian reds on the market are oxides of iron stained with madder, and, as stated in a previous chapter, when oxide of iron is thoroughly burnt so that it contains no water of combination, it does not decompose madder lake. Tuscan red dries very well and is very reliable.

### ULTRAMARINE BLUE

Ultramarine blue whether it is artificial or genuine is chemically the same, with the one difference that the genuine ultramarine blue is the powdered mineral known as lapis lazuli, and ordinarily is the blue known under that name, but the mineral itself is found at times in an impure state either admixed with slate or gang-rock, or contaminated slightly with other minerals, and the genuine ultramarine blue may run, therefore, from a very deep blue to a very pale ashen blue, in fact, the lapis lazuli which lies adjacent to the gang-rock is ground up and sold under the name of ultramarine ashes, which is nothing more nor less than a very weak variety of genuine ultramarine blue.

From the standpoint of exposure to light or drying quality, the artificial ultramarine is just as good as the genuine, and the only advantage that the genuine has over the artificial is that the genuine is not so quickly affected by acids as the artificial is.

It may be of interest to know that in 1814 Tessaert observed the accidental production in a soda oven at St. Gobain (France) of a blue substance which

Vanquelin declared to be identical with lapis lazuli.

In the following year the same observation was made by Huhlmann (at St. Gobain, in a sulphate oven) and by Hermann in the soda works at Schoenebeck (Prussia).

In 1824 La Societe'd'Encouragement pour Industrie offered a prize of 6000 francs for the production of artificial ultramarine which, in 1828, was awarded to J. B. Guinet, a pharmacist of Toulouse, later of Lyons, who asserted that he first produced ultramarine in 1826. Vanquelin was one of the three "trustees" holding the secret contrary to the rule of the Societe'.

In December, 1828, Gmelin of Goettingen explained his process of making artificial ultramarine before the Acadamie des Sciences of Paris. He used as the basis a mixture of precipitated hydrate of alumina and silex, which was, later on, superseded by China clay (kaolin).

In 1829 Koettig produced ultramarine at the Royal Saxon Porcelain factory at Meissen.

In 1834 Leverkus, at Wermelskirchen, and later at Leverkusen, on the Rhine, produced the pigment.

In 1837 Leykauf & Zeltner, at Nueremberg, introduced the manufacture of ultramarine into Germany.

Prices of ultramarine in 1830:

| | |
|---|---|
| Natural | $50.25 per pound |
| Artificial | 4.05 per pound |

Ultramarine is composed of alumina, silica, soda and sulphur, as follows:

Ultramarine (pure blue) containing a minimum of silica seems to be a more or less well defined chemical body, i. e., a double silicate of sodium and aluminum with sulphur as a poly-sulphide of sodium, or as a thio-sulphate.

| *Ultramarines* | *Poor in Silica* | *Rich in Silica* |
|---|---|---|
| Alumina | 29 | 23.70 |
| Silica | 38.50 | 40.80 |
| Soda | 22.50 | 19.30 |
| Sulphur | 8.20 | 13.60 |
| Undecomposed | 1.80 | 2.60 |
| | 100.00 | 100.00 |

R. Hoffman gives the following proportions:

| | *Alumina* | *Silica* |
|---|---|---|
| Poor in silica | 100 | 128 |
| Rich in silica | 100 | 170 |

In resistance to alum the different products rank as follows:

| | |
|---|---|
| Lapis Lazuli | first |
| Artif. Ultramarine (rich in silica) | second |
| Artif. Ultramarine (poor in silica) | third |

In 1859 Leykauf discovered the purple and red varieties of ultramarine which were produced by the action of hydrochloric and nitric acids, and by heating ultramarine with calcium chloride, magnesium chloride and various other chemicals. In this way there were produced a variety of shades, and by the addition of such substances as silver, selenium and tellurium, even yellow, brown, purple and green shades were produced.

All of these colored ultramarines are exceedingly permanent to light, but have little or no hiding power, and when used alone are perfectly permanent.

The ultramarine blue which is made by means of a potash salt instead of a soda salt has every analogy of color and shade to genuine cobalt blue, excepting that the genuine cobalt blue is not affected by acids as rapidly as the artificial.

### ULTRAMARINE, GENUINE (See Ultramarine Blue)

### ULTRAMARINE ASH

This may be called a weak variety of ultramarine blue either artificial or natural. It is obtained when artificial ultramarine blue is mixed with clay, or when natural lapis lazuli is mixed with the gang rock or native earth that surrounds it. Both the genuine and the artificial ultramarines are perfectly permanent when used alone, and permanent when mixed with zinc white and cadmium yellow, but not permanent when mixed with flake white or any color that may contain lead.

### VANDYKE BROWN

Vandyke brown is a native earth, and is identical with cassel brown. It is popularly supposed that Vandyke first used this pigment as a glazing color in place of bitumen, and as it is composed of clay, iron oxide, decomposed wood and some bituminous products, it is fairly translucent and adapts itself for glazing purposes. Because of the bitumen which it contains, it dries very badly and very slowly, and has a tendency to crack or wrinkle if the under-coat is either too hard or too soft. Concerning its permanence, there can be no doubt that it darkens considerably on exposure like all the bituminous compounds, and many painters use a permanent glaze composed of a mixture of ochre and black tinted with umber. Where the effect of age is to be simulated, there is no objection to its use.

### VANDYKE MADDER

This is a madder lake mixed with either Vandyke brown, umber or black. If the artist prepares the pigment himself, it is safer for him to use lamp black and madder lake, for the iron content of Vandyke brown or umber have a decomposing effect upon the madder.

### VENETIAN RED

This is a pure bright form of oxide of iron which in the early days was a native hematite, selected by the artist for brilliancy of color. It was also made by the early Italian painters by calcining ochres and siennas, and then selecting the product as to shade and brilliancy. Venetian red is permanent, dries well, and is reliable, but has a tendency to darken when exposed to bright light. The Venetian red of commerce is a mixture of gypsum and oxide of iron which is more permanent to light than the pure oxide of iron, and neither fades nor darkens, but should not be mixed with any lake. It dries well, and has complete hiding power. It is frequently used as a mixture with white as a ground color for portrait painting, but should always be permitted to dry most thoroughly before being painted over, for the reason that it dries so hard that it may crack under subsequent painting.

### VERDIGRIS

This color is produced by subjecting copper to the action of vinegar, and is therefore a form of acetate of copper. When used alone, and properly protected, it is fairly permanent to light, but has a violet chemical action on every one of the organic pigments and lakes, and affects many of the inorganic pigments. It is popularly supposed that the ancients used it as a glazing color, but this is very doubtful, in view of the fact that the ancients worked more with malachite green than they did with verdigris. It is thoroughly unreliable, and should not be used, even though it may not fade. It is affected by sulphur gases and dries slowly.

### VERMILION, PALE, MEDIUM AND DARK

(See French Vermilion)

## VERONA BROWN

Verona brown is a fancy name given to a mixture of burnt sienna and burnt umber, or raw sienna and burnt umber. It is a permanent color, unaffected by, but has a deleterious action on, some of the lakes. As a glazing color, it is reliable, and is to be recommended.

## VERONESE GREEN

It is supposed that Paul Veronese was the first painter to use this pigment, and if he did, it is very likely that the green he used was a mixture of raw sienna and permanent blue (lapis lazuli). There is a tradition that the original Veronese green was terre verte or ground green earth, but green earth is so exceedingly weak and such an indistinct green that it is more than likely that the former combination was the original green. When raw sienna and permanent blue are mixed they form a permanent and reliable pigment.

## VIOLET CARMINE

It would appear that this pigment is made from the hypernic wood or Brazil wood, and as such is thoroughly unreliable from the standpoint of permanence. Similar shades can be made by mixing madder with other pigments which would be permanent, and therefore violet carmine, when made from a wood lake, has no place on the painter's palette.

### VIRIDIAN

This is a form of chrome oxide which is quite transparent, and while not very brilliant as compared, for instance, with emerald green, is a thoroughly safe and reliable color. It evidently has been known for many years, and when exposed to the light does not show any perceptible change, nor is it affected by any gases in the atmosphere. It has all the characteristics of oxide of chromium, and has the same chemical composition with the addition of water as a hydrate or water of combination. In its effect it is similar to a lake, and can be used for glazing. It forms a valuable pigment for the painter, and is thoroughly reliable. It dries well.

### WARM SEPIA

This is generally made by mixing a sienna or ochre with madder lake. As a mixture for oil painting, this mixture is very undesirable, for the iron in the ochre or sienna decomposes the madder, and as a water color the same result is obtained, with the exception that it takes much longer to manifest itself. This color is not to be recommended.

## YELLOW CARMINE

This pigment is a misnomer, there being no such thing as yellow carmine. The pigment sold is a yellow lake similar to Italian pink or Dutch pink, fades very rapidly, is quickly decomposed, and has no merit whatever.

## YELLOW LAKE

All yellow lakes which the author has examined are in the same class with Dutch pink, Italian yellow, yellow carmine, etc., and are thoroughly undesirable. The author has, however, made a yellow lake from paranitraniline which is intensely powerful, has ten times the tinctorial power of quercitron lake or Dutch pink, and has shown itself absolutely permanent when used alone for over one year, but when mixed with the metallic pigments, it does not bleach but darkens. The author has not made this with any commercial purpose in view, but simply as a matter of experiment, for the purpose of producing a permanent yellow glazing color. There is no reason why the reputable tube manufacturers should not produce a perfectly permanent yellow lake.

## YELLOW OCHRE

This is a native clay colored with about 20 per cent. of iron rust previously described under the head of

Roman ochre, etc., very permanent, and can be mixed with other mineral pigments. It has the same destructive effect upon the lake colors that the sienna earths and other ochres have. When exposed to the bright light for a year, it has a tendency to darken very slightly. It is a good drier.

### ZINC WHITE

This is a pure form of zinc oxide, permanent under any and all conditions, but having the defect of drying very hard. To overcome this it should always be mixed with pure raw unbleached linseed oil, and although it is a very slow drier at first, its drying is progressive, for it evidently combines with the linseed oil. It has been suggested by some writers that zinc oxide should be mixed with beeswax or castor oil, or other semi and non-drying compounds, but such advice should by no means be followed. When zinc white is mixed with a semi or non-drying medium and exposed to bright sunlight in the summer time, it is very likely to sag and run, even years after it has been applied. There is a great deal of discussion concerning the transparency or lack of opacity of zinc white, but this is largely a fiction. Any painter, who uses a color in microscopic quantities, cannot expect it to hide the pigment over which it is placed. Zinc white liberally applied, one one-hundredth of an inch thick, for instance, will totally obscure black, while many painters apply their colors to the depth of one-eighth of an inch.

Zinc oxide is popularly supposed to be unaffected by sulphur gases. This is not strictly true. It is affected by sulphur gases just as quickly as white lead, the difference being that the result in the case of zinc oxide is not visible, because the sulphur compounds of zinc, such as the sulphide with sulphureted hydrogen, sulphite of zinc with sulphurous acid, and sulphate of zinc with sulphuric acid, are all white compounds, just as white as the zinc oxide itself, while lead forms a black compound with sulphureted hydrogen. Hence, we assume that these gases do not affect zinc, because we cannot see the result, but chemically we know that they do. Zinc oxide can be mixed with any color and may be freely used.

## ZINNOBAR GREEN, LIGHT, MEDIUM AND DARK

Because Zinnobar red or Zinnober was a permanent red, some manufacturers have made a Zinnobar green, and have sold it more or less on the implication of excellence on account of the name.

Zinnobar green of commerce, which is now made by only a few tube manufacturers, is a mixture of Prussian blue and chrome yellow, sometimes reduced with whiting and sometimes with zinc. In any case, this color should not be used, and while it is not as fugitive as emerald green, and not as quickly affected as a green lake, there are too many conditions under which this color may fail, and therefore it is not to be recommended. It is quite natural to suppose that this color has all the defects of Prussian blue and chrome yellow both as to decomposition and actinic quality, yet a sample of Zinnobar green, deep, used alone and allowed to dry before being varnished over, will not show any decomposition for two years, but as there are other more permanent greens for the painter to use, it is far wiser for him not to use Zinnobar green on his palette.

## CHAPTER XV

## THE PERMANENT COLORS

THE following is a list of pigments which can be mixed with each other or used separately, and which are not affected by light, nor do they interact upon each other:

Lamp black
Ivory black
Graphite
Plumbago, or any form of carbon or carbonaceous black
Zinc white, or any form of oxide of zinc
Permanent white, or any form of artificial barium sulphate
Venetian red
Indian red
Burnt umber
Raw umber
Raw sienna
Burnt sienna
and the various mars reds, orange, brown and purple.
Oxide of chromium, transparent
Oxide of chromium, viridian
Terre verte

The vermilions made from sulphide of mercury.

Blue, ultramarine blues, native or artificial

Brown, burnt umber and all oxide of iron browns.

Cadmium yellow to orange.

From a chemical standpoint these are practically the only colors which may be mixed with each other that will not react, and I have purposely omitted a number of so-called permanent colors in this schedule, such as, for instance, the madder colors, which I find will decompose when mixed with ochres, as well as if a faint trace of acid is left in the oil. I have omitted the madder lakes, for although they are permanent, they cannot be indiscriminately mixed with other pigments.

## CHAPTER XVI

## PIGMENTS DANGEROUS TO HEALTH

NEARLY all of the pigments are poisonous, and as some artistic painters from time immemorial have been accustomed to use the fingers in shading and in grading tints, particularly in portrait work, it is essential to know which of the colors are poisonous and which are not, as pigments may easily be absorbed through the skin as well as by taking them internally. In medical practice, for instance, a solution of iodine is painted on the skin and is absorbed in that way into the system. So likewise it is possible to absorb colors through the skin, particularly under the finger nails. The unbroken skin is supposed to be impervious, yet lead poisoning may result through the actual manipulation of lead pigments, and it behooves the painter to be very careful in the use of his or her fingers in the manipulation of certain pigments.

The worst results are produced by the use of lead pigments, for it appears that the arsenic and copper pigments which are more poisonous if taken internally are not so easily absorbed through the skin.

First in the list of dangerous pigments is flake white, which is easily absorbed and produces lead poisoning. Many painters have the habit of blending colors on the palms of their hands either with a brush or with a finger, and due care should be taken to remove the colors as soon as the desired effect is produced on the canvas. The pigments which are absorbed into the skin are flake white, chrome yellow, chrome green, Naples yellow, red lead and orange mineral. These are the lead colors principally used. The arsenic colors are Paris green, emerald green and orpiment. There are a number of other poisonous colors such as mercury vermilion, verdigris, etc., which are, however, not frequently used by the painter. Prussian blue which is a cyanide blue is supposed to be a poisonous color, but in reality it is not. Zinc white, permanent white, baryta white and ultramarine are non-poisonous. All the blacks, siennas, umbers, ochres, carmine, red oxides and many of the lakes are non-poisonous, but the best rule to follow is to clean the hands with soap and water after having stained them with colors.

## CHAPTER XVII

## PIGMENTS WHICH ARE AFFECTED BY SULPHUR GASES AND COAL SMOKE ALSO THE PIGMENTS WHICH ARE AFFECTED BY LIGHT

IT has been demonstrated by numerous writers, and particularly by Prof. Chas. Baskerville * that in all large communities there exists sulphuric acid in the

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* Baskerville made a number of determinations of the sulphur dioxide content of the air of New York City. Stations were established throughout greater New York, including the high office buildings, parks, subways, and railroad tunnels. Very variable results, as might be expected, were obtained.

The determinations may, in part, be thus summarized:

| *Locality* | *$SO_2$ in parts per million* |
|---|---|
| Elevated portion of the city near a high stack | 3.14 |
| Various parks | 0.84 (maximum, others negative) |
| Railroad tunnels | 8.54—31.50 |
| Subway | None |
| Downtown region | 1.05—5.60 |
| Localities near a railroad | 1.12—8.40 |

A total quantity of 1300 tons of sulphur dioxide, calculated as 80 per cent. sulphuric acid, is discharged every twenty-four hours into the air of New York City from the combustion of coal alone.

From an economic standpoint, this is an enormous, partly avoidable, waste, while from a sanitary standpoint, any disinfecting action it exerts on the organic wastes arising from the streets is greatly counterbalanced by its general injurious effects.†

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† Paper read before the Society of Chemical Industry, Feb., 1909.

These may be thus summarized:

1. Its presence in atmospheric air is a menace to hygienic welfare, since it has serious effects on susceptible persons and particularly exerts deleterious effects upon the respiratory organs. $SO_2$ in the air of manufactories tends to produce bronchitis and anaemia.

2. It exerts an injurious action on plant life. In this action, it is less violent than hydrogen chloride, sulphuric acid, and fluorine; but owing to its less solubility and consequent slower condensation it has a wider distribution. In Manchester, England, in 1891, it was learned that the greatest injury to plant life is due to the emanations from dwelling houses.

3. The condensation of sulphurous acid with moisture in fogs and hoar frosts seriously affects goods printed with colors sensitive to sulphurous acid; for example, logwood, Brazil wood shades, and aniline black.

4. Sulphur dioxide proceeding from the combustion of coal and coal-gas, the quantity of which in towns is considerable, necessarily destroys the ozone of the air. This may account for the definite variations of the proportion of ozone observed at various localities.

5. In anti-cyclonic periods the amount of sulphur dioxide rises considerably and at such times this increase is accompanied by at least as large an increase in the amount of organic impurities. (Baskerville.)

Where there is much soft coal consumed in a certain district, the brick and stone become coated with particles of carbon. This deposit causes marble and other light-colored materials to take a funeral aspect and not only that, it causes some stone to decay. St. Paul's Cathedral in London is a notable example of this as shown by Church. In other cases the sulphur gases attack the mortar or cement. This is due to the fact that sulphur dioxide accumulates on the soot and other solids, where it is oxidized to sulphuric acid.

In the manufacture of sulphuric acid used for purifying crude oil and for other purposes, the escape of sulphurous acid fumes from the Exits often constitutes a decided nuisance. Not only is vegetation injured and often killed in nearby sections, but the health of the residents in the neighborhood is injuriously affected by breathing the poisonous vapors, throat troubles of a chronic nature often resulting. However, injuries are often attributed to sulphuric acid factories, when in fact they are innocent. Compliance with the requirements of the English Alkali Act of Lord Derby, effectually prevents any serious injury. Temporary discomfort and even serious injury may result, however, through an accident in the works. Manufacturers wish to avoid and also prevent the escape of sulphur dioxide, for all that is lost diminishes profits. Corrective devices are applied by the works' owners.

air, and many of the colors which we have regarded as permanent to light, are not permanent to the effects of acid gases. In a general way this rule applies also to the colors affected by sulphureted hydrogen. If we take, for instance, red lead, which is the red oxide of lead, and expose it to the air of a city, it apparently bleaches white. The same red lead when varnished and covered with glass may be exposed for ages, and will not be affected. We note the former change particularly on steel structures like bridges which have been painted with red lead and on which the color sometimes bleaches from a pure scarlet to a pale pink. On rubbing such a surface with linseed oil and turpentine the original color comes back in all its brilliancy. Upon investigation, we find that the sulphuric acid has affected the color and formed a minute crystalline surface of sulphate of lead, which is white. Chrome yellow will be affected in the same way. Improperly washed prussian blue will likewise bleach, and flake white is affected in identically the same manner, with the exception, that the change cannot be noted by the eye, but if a flake white surface which has been exposed to the elements is rubbed with a black cloth, a white chalky deposit will stain the cloth. This is known as chalking, and mural decorations which cannot very well be varnished and protected, should therefore be executed with pigments that are not affected by the acid gases of sulphur. Nearly all the pigments are affected, with the exception of the blacks. The ochres, siennas and the earth colors which are exceedingly permanent show this defect to a less degree, although, as compared with the chemical colors like prussian blue, the lakes, cadmium yellow and the lead colors, but paintings which are kept in a pure atmosphere under glass are necessarily preserved, and water colors are more susceptible than any other form of painting.

These acid gases are produced during the burning of coal, and as the combustion of coal is more or less incomplete, soot may deposit upon the surface of a painting, particularly decorations in a locality where soft coal is used. This is particularly true of localities like Sheffield, England; Pittsburgh, U. S. A., and Chicago, U. S. A. There are, however, many paintings such as, for instance, the Horse Fair by Rosa Bonheur, which cannot be covered by means of glass, and paintings of such magnitude should be kept carefully varnished to prevent any disintegration from the acid gases. The canvas upon which most of these large paintings are executed is either composed of flax which is equal to linen, or cotton fibre, or a mixture of both, and these fabrics are particularly susceptible to the action of acid gases. The chemical method of determining the difference between cotton and wool consists in dissolving out the wool with caustic potash, which leaves the cotton intact, and vice versa, we may take an acid re-agent which will not attack the wool but will dissolve the cotton. In time, therefore, the canvas would be weakened, and its strength reduced through the action of these moist acid gases, which demonstrates the advisability of either painting the back of a canvas, or mounting it upon a wood or metal support. In the case of a very large painting a sheet of metal could not be fabricated which would be sufficiently light and rigid for this purpose, but a seasoned wood support could be constructed. However under all circumstances the back of the canvas should be painted to prevent this disintegration.

In case a canvas is very thin, and there is danger of the protecting coat on the back soaking through, it is advisable to put on a thin glue size before applying the protective coat.

In this list must be included all colors which contain metallic bases, such as lead, copper and antimony. The colors which are affected are as follows:

| | |
|---|---|
| Flake White | Naples Yellow |
| Silver White | Chrome Green |
| Cremnitz White | Paris Green |
| Lemon Yellow made of chrome yellow | Emerald Green |
| Chrome Yellow | Verdigris |
| | Zinnober Green |

## CHAPTER XVIII

## WATER IN TUBE COLORS

UNDER normal conditions, if you take heavy pigments like white lead, oxide of iron, etc., and grind them in linseed or poppy oil, the oil will eventually float to the top and the pigment will settle hard to the bottom, yet nearly all the tube colors remain soft and fresh, and apparently the law of gravity is overcome in some way.

A large number of the colors are kept in suspension because the manufacturer adds water to the oil, and makes an emulsion which keeps the pigment suspended. This is particularly true of the whites, and it must be admitted that a small percentage of water added to the pigment or the oil during the process of manfacture does not do any ultimate harm, yet, some tube manufacturers use such an excessive quantity of water that where paint is very smoothly applied the water evaporates quite rapidly and leaves the subsequent film in a spongy, porous condition. If a picture were to be put away in a perfectly clean atmosphere free from dust no harm would result, or if the precaution were taken to place a sheet of glass over the picture and slightly away from it, the picture would dry in

*High power photo-micrograph of Flake White which contains too much water in its composition. The uneven surface presents an excellent lodging place for dust and dirt which are hard to remove.*

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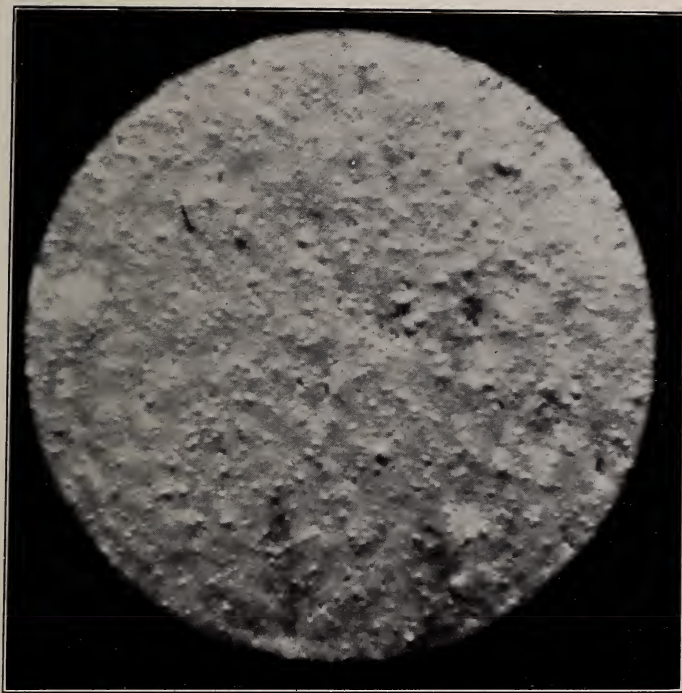

a perfectly clean condition, and would remain so until it were varnished; but this is not the case, so that if we examine microscopically a paint film which contains excessive water, we find that the spongy, porous condition of the surface is a lodging place for dust and dirt which cannot be readily removed for obvious physical reasons, and as it seems advisable to add water to nearly all of the tube colors which will settle out rapidly and heavily, it is well to acquaint the painter with this fact in order that the picture be not subjected to a dry atmosphere which is dusty.

## CHAPTER XIX

## THE PIGMENTS WHICH ARE ABSOLUTELY PERMANENT WHEN USED ALONE BUT ARE NOT PERMANENT WHEN MIXED WITH OTHER COLORS

Madder Lake
Antwerp Blue
Prussian Blue
Paris Blue
Vermilion made of sulphide of mercury
Para Red
Lithol Red
Harrison Red
Ultramarine Blue
Cobalt Blue
Hooker's Green (when made from Prussian blue and raw sienna)
Ochre
Flake White

The foregoing list of colors must be used with some judgment. Many of these colors are permanent when mixed with some other colors, but decompose when mixed with each other. For instance, yellow ochre and madder lake when used alone are permanent, yet the two when mixed will decompose.

## CHAPTER XX

## COLORS WHICH DRY SLOWLY AND IRREGULARLY

(FROM 3 DAYS TO 2 WEEKS)

Bone Brown
Alizarin Yellow
Crimson Madder
Carmine Lake
Crimson Lake
Brown Madder
French Carmine
French Carmine No. 2
Orange Cadmium
Gamboge
Capucine Madder
Mauve
Magenta
Indian Yellow
Brown Pink
American Vermilion
Madder
Alumina

Rose Pink
Transparent Black
Sepia
Scarlet Lake
Rose Doree
Alizarin Green
Yellow Lake
Payne's Gray
Italian Pink
Indigo
Lamp Black
Carbon Black
Olive Lake
Alumina & Prussian Blue
Sap Green
Violet Carmine
Vandyke Brown

Cork Black
and as a rule all of the Lake colors

## CHAPTER XXI

## THE FAILURE OF SIR JOSHUA REYNOLD'S PAINTINGS

ONE of the greatest portrait painters who ever lived and the man who made the most failures of his art, was Sir Joshua Reynolds, the obvious reason being that he was always after the search of the secret of the ancient masters, and as far as we can deduce, he never made a single investigation and hardly ever painted two pictures alike from the technical standpoint. During three years of his career, he painted on an average one portrait every three days. He was just as careless at times in his imitative style as he was in the selection of his pigments, for many of his clients refused to accept the pictures after he had finished them, because they did not resemble the sitter. It was his custom to paint simply the face and the hands, and permitted his students to fill in the dresses and the background. In nearly every one of his pictures that has faded and decomposed only the face and hands are affected, the rest of the picture being in perfect condition.

He kept a diary which was written in a jargon of

Italian, Latin, English and French, and every time he made a note, it appears as if he was sure that he had made a new discovery, and had at last found what he always thought was the Venetian secret.

The principal cause of his failure was the fact that all lakes were probably the same to him, and he usually mixed a lake with ochre, which is, of course, a radical mistake. During his life time many of his pictures had faded until the faces assumed the ghastly tint which in medicine is known to be due to chronic anaemia where the skin blanches and assumes a yellowish gray, and the line of demarcation around the lips is obliterated. This effect in his pictures is due to the fact that the lake which he used was not always madder lake, but weaker lakes produced from berries and wood, although even madder lake is incompatible with yellow ochre and with the siennas and umbers, so that none of the effects which he produced were permanent.

How strange is the comparison between the work of Sir Joshua Reynolds and that of Franz Hals and his contemporaries. Hals used practically the same colors but always glazed with madder lake after the undercoat was thoroughly dry. Painters, as a rule, know that no earth color or metallic color should be mixed with a lake, but yet a lake may be used over every one of the earth colors, including even ochre, provided the ochre has been allowed to become thoroughly dry. The one possible exception to this may be the use of madder lake mixed with English or Chinese vermilion, because vermilion is a very stable chemical compound and the madder lake is therefore not decomposed, with the possible exception that in time a mixture of madder lake and English vermilion will darken slightly when exposed to direct sunlight.

If painters will limit the colors used on their palettes to the least possible number and use only those which do not interact, as well as exercise a little judgment in glazing over colors only after they are thoroughly dry, absolutely permanent results will be obtained, and the mistakes made by the older men will not be without profit.

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ON

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