The Manufacture of White Lead

How the Great Paint Pigment is Made—Early History of Its Use

(Concluded from Dec. 17.)

Chamber Process.—The chamber process is largely used on the continent of Europe. As yet only one English company operates this method, and has done so since 1898. In America the chamber process finds no application. In Germany the method has absolutely displaced the Stack process: hence one frequently hears the process discribed as the "German Chamber Method."

As previously stated, the process is frequently ascribed to Creed, who obtained a patent in 1749, but the suggestion cannot be regarded as serious, as no commercial development followed the patent and for other reasons. The patent of an American, Burton,[25] in 1858, may be regarded as the first patented process in which the chamber process is clearly indicated. This has only historic interest, and the real development of the process is due to German workers.

The method is closely related to the Stack method, the differences being concerned solely with the means adopted for the more rapid and complete corrosion of metallic lead. The corroding chambers are brick constructions, in which strips of lead are hung from horizontal supports, and a mixture of air, steam, acetic acid, and carbon dioxide supplied through floor inlets. The composition and temperature of the mixed gases can be controlled to meet varying conditions—a feature of importance, and one which, when ideal conditions have been ascertained, is of great value. Corrosion is effected at a temperature of about 60 deg. C., and is complete in about 50 days. Before opening the chamber, it is the practice to blow in steam to damp the corrosions, thereby preventing the creation of dust during emptying. The chambers are emptied by hand, and the succeeding processes adopted are similar to those adopted with the Stack product.

Notes on the "Chamber White Lead."—Chamber white lead has certain characteristics by reason of the process adopted for its manufacture. Its color is excellent as no source of discoloration is normally present. Corrosion is usually more complete, i. e., more metal is corroded. In certain cases the product is more bulky than the Stack product but it is impossible to generalize in this connection.

Krem's Process.—This process can be described as being intermediate between the Stack and chamber process, as it resembles both in certain respects. The process is used only on a small scale—principally in Austria. Krem's white is a product valued for its good color, which feature is consequent not only on the process adopted, but also on the extreme purity of the metallic lead used. The quantity marketed is not sufficient to render it necessary to detail the process in this paper.

Miscellaneous Processes.—Under this heading we have to record the few survivors of a very large number of processes which were designed as improvements on the Stack process.

The only process applied in this country on any considerable scale other than the chamber or Stack process, is the "Bischof" process which is now in the possession of The Brimsdown Lead Co., Ltd., Middlesex.[26] In outline, this process consists in:

(1) The preparation of lead monoxide from metallic lead in cupellation furnaces.

(2) The reduction of lead monoxide by means of water gas to a black suboxide of lead.

(3) Oxidation and hydration of this suboxide to lead hydrate.

(4) Subsequent conversion of the lead hydrate into hydroxy-carbonate in special carbonators with pure carbon-dioxide, using lead acetate as catalyst.

It is claimed that the process gives absolute control of the composition of the final product, and in so far is unique, a statement borne out in practice. The product has a well-established position in the English market.

Another type of process which is in operation on a small scale in England, Germany, and Italy, depends on the direct oxidation of metallic lead by air in the presence of lead acetate, the basic acetate of lead so obtained being subsequently treated with pure carbon dioxide, or purified flue gases from the burning of coal or coke in order to obtain a precipitate of hydroxy-carbonate of lead. The quantity made by this type of process is small. They are adaptations of the original Thenard or Clichy process, and are novel only so far as the methods adopted for obtaining a basic acetate solution. Use is made of lead in powder form, in ribbon form, in so-called "feathered" form, the object of such variation being to obtain large surfaces for interaction. In some cases the solution is effected under pressure.

Carter Process.—This process is successfully applied in the U. S. A. and Canada. The idea of the process is to increase the rate of production of white lead from metallic lead by following the interactions of the Stack process as follows: Lead is granulated, then placed in revolving drums. Acetic acid and water is sprayed into the mass at intervals, whilst flue gas containing carbon dioxide is forced through the mixture. This is continued for six days; then the mass is disintegrated to prevent balling, and the carbonating process continued for another six days. The carbonated product is levigated to remove unchanged lead, and then filter pressed.

Matheson Process.— By this process some 4,000 tons are made yearly in the U. S. A. The process was invented by Dahl, and is similar in principle to the Carter process, but the method of application differs.

Hebrew Process.—This process is stated by Falk[27] to be in operation on a very large scale in certain parts of Russia, especially at Yaroslav.

Litharge containing 25 to 40 per cent of metallic lead is intimately mixed with 4 to 5 per cent of solid lead acetate, moistened with water, and thrown into compact heaps of 5 to 6 cwts. After 24 hours the heaps are sliced as fine as possible, and the material spread on linen stretched on frames, and placed in an atmosphere containing carbon-dioxide, often derived from a coke fire in the room itself at a temperature of 100 deg. Fahr. The percentage of carbon-dioxide is kept low, as it is found that a better quality product is obtained under these conditions. After three days' exposure the shredded material is taken out of the room, and formed again into compact heaps, and allowed to stand for one day, water being added to bind the material. The process of three days in the frames and one day in the heap, alternately, is continued from three to five months, the amount of water added being increased as necessary.

The material undergoes a series of changes in color, ultimately becoming white, and the process is complete when the material does not show gritty litharge or metallic lead if rubbed down between the fingers. The material is not washed, but mixed with water and kneaded by hand until it forms a homogeneous paste, which is allowed to dry in conical or plate form. It is stated that this product is preferred by buyers in northern and eastern Russia and in Siberia, and, further, that in spite of its grey or yellow color, when used as a paint it dries up white.

The hygienic aspect of the process will not bear investigation, and one is not surprised to learn that each factory has its own doctor, dispensary, and hospital.

All processes as yet described have involved the use of lead acetate as catalyst. There is, however, one process, viz., the Rowley or mild process, which is in use in the U. S. A., where this is not the case. The process is as follows:

Molten lead is converted into an impalpable dust by means of a spray of air and steam. The black sludge so obtained is then agitated in the presence of air and water,

12/31/1913

thus producing a so-called hydrated lead. The composition of this hydrated lead seems to be variable and uncertain. After a certain length of time the hydrated lead is removed by elutriation from the metallic lead, and the purified lead hydrate is directly converted into hydroxy-carbonate of lead by means of carbon-dioxide in rotary carbonators without the use of acetic acid. It appears possible that the mechanism of the interactions involved may be similar to that described by Clowes[28] as taking place under certain conditions when lead is exposed to air, water, and carbon-dioxide.

The processes described cover the whole range of those now in use on the large scale. As yet the electrolytic production of white lead has not been commercially established.

The processes so far described have differed in the methods adopted for the production of what is known as white lead pulp, i. e., a paste of white lead containing water in varying quantity. It must be noted that white lead at this stage should be free of lead acetate, a condition effected by washing with water, either in filter presses or by decantation. At this point the methods adopted by all manufacturers become common, and vary only in detail.

White lead is sold either as a dry powder or as an oil paste, containing from 6 to 9 per cent of linseed oil.

The drying of white lead is carried out in driers of various types, e. g., continuous band driers, drying in pots on shelves, vacuum driers, steam-heated copper pans. The whole aim of the manufacturer has been to effect the drying and handling of his dry material in such a manner as to prevent the creation of dust, and the dangers attendant thereon. I show slides illustrating some of the types in use.

White Lead Paste.—Oil paste in this country is prepared by one or two processes, either by the old-fashioned method of grinding the dried powder in linseed oil, or by the newer method known as "pulping." The older process is familiar to all, and requires no comments, but the new method has not had the publicity it deserves, and in some cases the published statements are inexact, and, to my mind, prejudicial to the advance of a method of working which ranks as one of the greatest hygienic advances in the manufacture of white lead during recent years. The method adopted is to take white lead water paste direct from the filter presses, and to mix the same with a predetermined quantity of linseed oil in a special pug mill or mixer. After about half an hour's mixing the mass suddenly changes in appearance, and it is found that the linseed oil has displaced the water in the paste, so producing a white lead linseed oil paste, from which the free water can readily be drained. Simple draining does not effect complete removal of water, as a certain quantity is mechanically retained by the paste, and in order to remove this the machine is closed up, and evaporation of residual water is carried out under reduced pressure at a carefully regulated temperature. The mixer is heated by steam jackets. This method is capable of removing the whole of the water mechanically retained, and I take this opportunity of correcting statements which have been made to the effect that pulped white lead invariably contains a considerable quantity of water. I have examined a large number of samples made by different makers, and find this not to be the case.

It will be realized that the process described obviates the preparation of dry white lead, and in this respect its hygienic value is evident. I feel that the process of pulping is worthy of more extensive application, and if adopted would contribute largely towards the reduction of risks to workers. The preparation and handling of dry white lead is by no means an enviable occupation, and I should be glad to see this branch of the industry decrease, as I am unable to see the real necessity of dry products being supplied in many directions. The sale of white lead water paste or damped white lead is much to be preferred. I notice an increasing tendency on the part of certain users to specify that their hitherto dry products shall be damped in order a prevent dust—a practice of great hygienic value.

There is some disagreement as to who was the inventor of the process of wet pulping, it being ascribed to Lefevre of Lille, and to Expert Besancon of Paris.[29] The process appears to have been first worked in England by Ismay[30] about 1895, and since that time the principal improvement, e. g., vacuum work, is of English origin.

After incorporation of the white lead with oil, as before described, the paste is passed through granite roller mills, and packed ready for the market, or converted into ready-mixed paint, although as yet the latter trade is not developed in England on a scale comparable with that in the U. S. A.

Chemistry of White Lead and Its Manufacture.—It is apparent in all the processes now in operation, save the Mild process, that the formation of white lead is dependent on certain interactions taking place between metallic lead, acetic acid, water, carbon-dioxide and air, and that the final product is a hydroxy-carbonate of lead. I have deliberately chosen the expression "hydroxy-carbonate of lead" because I consider it is the only correct designation we can apply in our present state of knowledge.

Prior to 1774 white lead was considered to be a compound of calx of lead with vinegar, i. e., a compound of oxide of lead with acetic acid. In 1774 Bergmann (1755-1784) investigated the product chemically, and as a result terms it "luftsaurer blei-kalk," or "calx plumbi aerata," which in the English of the period was "fixed air and lead calx," meaning at the present time carbon-dioxide and lead oxide.

The next important inquiry made was that of Hochstetter (1829-1884) and Liebig (1803-1874)[31] who investigated the chemistry of the process of white lead manufacture carried out in the Stack method, and expressed their conclusions in a series of equations, which they considered as explanatory of the chemial changes taking place, viz.:

(1) $2Pb + 2H_2O + O_2 = 2Pb(OH)_2$.

(2) $Pb(OH)_2 + 2CH_3COOH = Pb(CH_3COO)_2 + 2H_2O$.

(3) $Pb(CH_3COO)_2 + 2Pb(OH)_2 = Pb(CH_3COO)_2 2Pb(OH)_2$.

(4) $3[Pb(CH_3COO)_2 2Pb(OH)_2] + 4CO_2 = 2[2PbCO_3 Pb(OH)_2] + 3Pb(CH_3COO)_2 + 4H_2O$.

It is obvious from the above that lead acetate acts as a catalyst and that white lead is considered to have the composition $2PbCO_3 Pb(OH)_2$, a compound of two molecules of lead carbonate with one molecule of lead hydrate. The formula appears to be usually accepted as correct. Acetic acid is the acid which has come into general use, because it is a commercial commodity and very effective in action. It is difficult to understand why patents were taken out for the use of butyric, valerianic, propionic, and other expensive and not more effective agents.

Personally, I feel that the processes operative, not only in the Stack method, but, indeed, in all processes, are to be explained by interactions other than those suggested above.

Liebig and Hochstetter were the first to recognize that white lead was a compound of carbonate and hydrate of lead. It is curious to notice how the old idea that white lead is a mechanical mixture of hydrate and carbonate of lead still persists in certain quarters. Harland and Wigner[32] claimed to have shown this to be the case, but all modern evidence is against their statement. It is by no means uncommon to hear stated that the hydrate portion of white lead gives it the spreading power, whilst the carbonate portion supplies only opacity, and that the value of white lead is the arithmetical relationship between these constituent parts. Unfortunately this is not the case. It was with much surprise that I found in a reputable English publication[33] the following statement:

"White lead is a mixture of carbonate and hydroxide of lead, and always contains some combined water."

In all processes, with the exception of the mild process, the rational appears to be the same, and it becomes necessary to consider the action of carbonic acid on basic acetate of lead, in order to elicit some information as to the first stage in the process.

I am fully convinced from experimental work that the decomposition of basic acetate of lead does not follow the steps indicated by the above equation, and that the first product is a hydroxy-carbonate of lead having a lower carbonic acid content than is indicated by the formula, and that this lower carbonate of lead subsequently takes up carbon dioxide, thereby increasing its CO_2 content.

It is necessary that this should be so, inasmuch as white lead is known, and is on the market, containing less carbon dioxide than that demanded by the prescribed formula.

Thompson (loc. cit.) is of the opinion that the first product of precipitation is a basic carbonate, plus a quantity of basic lead acetate. It appears to me that white lead is a mixture of hydrated carbonates of somewhat varying composition. This is indicated by the observation that if a corrosion is taken from a stack, the composition of the crust varies from the outside inwards, the external coating containing more carbon-dioxide than the coating nearest

to the lead, indicating that the external coating, having been the first formed, has undergone a process of carbonation. In some corrosions, I have found that no layer contained sufficient carbon-dioxide to satisfy the simple formula $2PbCO, Pb(OH)_2$.

If a stack corrosion is continued too long, or if, indeed, any process is carried out too long, a normal carbonate is formed, which is useless as a pigment.

It is not possible here to discuss fully the chemistry of the processes or products, but I wish to protest against the present day worship of the empirical formulæ for white lead which are so frequently encountered, varied occasionally by landscape gardening designs of so-called (though quite unjustifiably) constitutional formulæ. White lead is the product of a series of interactions, which proceed simultaneously, with the result that it has a complex chemical composition, and it is not possible from a chemical analysis to determine its value as a pigment. For recent discussion as to the formula of white lead, see Falk[4], Hof[5] and Sacher[6].

White lead is not a product of uniform size, and it is probable that many of its valuable properties can be attributed to this. It is also probable that the poor qualities of the products prepared by precipitation by means of alkaline carbonates may be ascribed to the homogeneity of the product, and, further, that all successful processes are such that the hydrated carbonate first formed remains in an atmosphere of carbon-dioxide, and undergoes further carbonation.

It must be pointed out here that the term "precipitated lead" has of late years acquired a very narrow and incorrect meaning. In the ordinary chemical sense, all white leads are "precipitated," being the solid products derived from the interaction of carbonic acid gas and basic lead solutions; even though the amount of liquid present in the stack and similar processes is small, the precipitation is just as real. The final product depends on conditions of precipitation, and full knowledge of this difficult phase of the problem is necessary before any satisfactory process can be produced.

Thompson,[7] by the use of an ingenious elutriator, has been able to separate white lead into constituents of varying size. The following table shows the fractions obtained, the word "cone" being used to designate a receiver for each sized fraction:

Cone 1	3.42 per cent.
2	6.41 " "
3	6.61 " "
4	8.70 " "
Finer than 4	74.85 " "

Some years ago, a theory was formulated in which a paint film was likened to concrete, and this theory has been responsible for the suggestions that the rigidity of a paint film might be increased if a pigment of various sized particles be prepared, so as to obtain what is known as a reinforced effect. I know from personal experience there appears to be some advantage in mixtures of products of various sizes, but there is no doubt that the reinforced theory is overdone by some of its exponents.

The real use of photomicrography is well illustrated by Thompson's work in distinction to many imaginary uses to which this valuable method of inquiry has been applied in certain directions in connection with paint materials and their application. The difficulty of preparing a representative sample of certain products is enormous, when their heterogeneous character is considered in relation to the size of sample required for microscopic work. I do not wish to be misunderstood in this connection. No one realizes more than I the value of this comparatively new method of inquiry, and my remarks are to be considered as a protest against the present tendency to photomicrograph anything and everything related to the paint industry, with total disregard of the elementary factors governing such an inquiry.

Sabin's[8] gingerbread story has a wealth of meaning. It is a comparatively simple matter to make a photomicrograph, but the true interpretation of the photograph is often a very difficult problem.

In the past, considerable discussion has taken place on the supposed saponification of linseed oil by white lead, when the two are ground together in the form usually marketed. It is frequently held that interaction takes place with the formation of a lead salt with the fatty acids of the oil, and that many of the valuable properties of white lead are to be ascribed to the presence of this organo-metallic compound. Long storage of the paste before use is supposed to increase the extent of saponification, and the so-called superiority of old white lead is explained on these lines. Hannay[9] first challenged this assertion, and stated that he was unable to detect the presence of any such compound, and, further, that he was able to wholly extract linseed oil from a linseed and white lead paste. Harland[10] disputed the statement of Hannay, and in 1907 an investigation was made by Davis and myself[11] in this connection. We found that it is impossible, even after prolonged extraction, to wholly remove fatty matter from the solid pigment, and, further, that the extracted linseed oil invariably contained lead, although, in each case, the extent of interaction is extremely small. Further work indicates that the phenomena is to be explained in the following lines:

The free fatty acids of linseed oil are partly converted into lead salts. This is proved by the decreased acid number of linseed oil after extraction from such a paste. The presence of organic matter in the extracted pigment is to be explained by the formation of—

(1) Lead salts of saturated fatty acids, e. g., stearic acid, and the like.

(2) By the formation of lead salts of unsaturated fatty acids, which have undergone oxidation since formation, both classes of salts being insoluble in ether or the usual solvents.

The lead which is invariably found in the extracted oil is due to the formation of soluble lead salts from the unsaturated fatty acids, and I am of the opinion that interaction takes place entirely between the white lead and the free acids of the oil. I have not been able to detect saponification. It is obvious that the quantity of organo-metallic salt produced is extremely small—in normal cases well under 1 per cent, and I consider it absolutely proved that the old saponification theory is untenable in the face of recently ascertained facts. It seems to me by no means improbable that the formation of even this small quantity of compound throughout the whole combined mass would have a beneficial result, and I have found that the same type of change takes place when basic sulphate of lead is ground in linseed oil.

The extent of interaction is increased by storage to a certain extent, but, as previously mentioned, the total change taking place is comparatively small.

It is suggested on what appears to be a sound basis that the changes taking place during storage are produced immediately when wet pulping is resorted to. This may, or may not, be the case. As yet I cannot express an opinion. I think with Holley (loc. cit.) that prolonged storage may induce physical change to a certain extent not yet appreciated, and it is by no means improbable that the effect of pressure as is produced by the weight of the superincumbent mass is not to be disregarded.

The ultimate composition of a white lead linseed oil skin has not been investigated with any accuracy, and I am unable to state whether in the process of drying saponification takes place, and that the resultant film may be considered to contain a large quantity of lead linoleate.

White lead has certain uses other than for painting, e. g., pottery glazing, manufacture of colored pigments, etc., but it is estimated that in England only about 15 per cent of the white lead used finds application for purposes other than for paint making.

It is often stated that white lead is frequently adulterated, but this is not the case in England. It has been my experience that the bulk of the white lead circulating generally is not seriously adulterated. In England makers have agreed to a recognised scale of so-called reduction, which consists in the addition of barytes in standard amounts, as indicated by the various grades of reduction. English white lead, containing any adulterant, is known as "reduced white lead," an expression perfectly understood by both maker and buyer, whilst the pure article is sold as "genuine English white lead"—a title of unmistakable meaning.

There is no doubt that years ago adulteration of white lead took place to a considerable extent, but largely owing to the action of white lead manufacturers themselves, this has decreased. In the interests of the trade, the White Lead Section of the London Chamber of Commerce undertake the analysis of any sample of white lead, free of charge, and should adulteration be proved, will undertake the prosecution.

Analysis of White Lead.

The analysis of white lead is worthy of some little attention in a paper of this description, because it is necessary to draw your attention to the very unsatisfactory position of affairs frequently obtaining in England.

In divers text-books methods are given by which the painter is supposed to be able to test his white lead for purity—the two most frequently found being the "burning test" and the "solubility test." The following quotation from a recent (4th) edition of a well-known work is typical:

"White lead may, of course, be tested for quantitative adulteration by analysis, but there are many rough-and-ready tests based on chemistry that will suffice for the painter to discover whether he is getting genuine white lead or white lead with earthy matter added. One of the easiest is to put some white lead in a ladle and convert it into blue lead by heat, weighing both the white lead and the resultant piece of metallic lead, and comparing notes and noting whether any dross or earthy particles are left in the ladle unconverted. If the white lead is pure, it should weigh about 10 per cent more than the lump of blue lead recovered from the ladle, the 10 per cent representing the weight of the oil in which it was ground.

"Another method is to mix the paste white lead to a paint with sulphuric acid, using a glass slab and a thin strip of glass. If the paste mixes into a smooth paint without effervescence and the production of vaporous fumes, it may be regarded as pure.

"Dry white lead may also be tested for earthy matter by dissolving it in nitric acid. Any sediment that will not dissolve is china clay, barytes or a similar adulterant. The test should be conducted in a small phial or test tube."

Reviewing the mystic rites in the order quoted, it is obvious that:

(1) The "burning test" as described would procure the condemnation of any lead product containing less than 100 per cent pure metal on the dry material, so that white lead with its 80 per cent of metal would be severely taxed to secure approval on this basis.

(2) Is inexplicable, particularly as to the "vaporous fumes."

(3) Is chemically unsound. Any soluble adulterant would not be revealed, no mention is made of the necessity for preliminary extraction of oil, and finally, as no strength of acid is named, the insolubility of lead nitrate in nitric acid is ignored.

The painter should stick to his painting and leave the chemist to do the analysis, and so save the vexatious waste of time which white lead manufacturers suffer through the application of rough-and-ready tests of the above type.

The ordinary analysis of white lead consists in the determination of the purity or extent and nature of adulteration, and the PbO CO_2 and H_2O content of the material, coupled with a determination of the nature and quantity of the oil, acetate of lead and uncombined water.

For methods see Walker [45], Davis and Klein[46], Thompson[44], and Holley[48].

Hygiene.

I now come to the subject of lead poisoning—a question much in the public eye during the last few years, and one quite worthy of considerable attention. It is unfortunate that owing to the efforts of sensational writers, of

well-meaning but uninformed philanthropists, and, finally, of professional agitators, the true position of affairs has been successfully obscured, and one not infrequently meets people to whom the terms white lead and certain death are synonomous.

The figures I propose to lay before you are not the result of my own imagination. In every case they are official figures[4], obtained from official sources, and are therefore capable of verification or refutation.

The poisonous character of lead and its compounds has been known since very early times.

Hippocrates (460 B. C.) describes lead poisoning. Vitruvius (100 B. C.) was cognizant of the danger of lead poisoning from water conveyed in leaden pipes. Dioscorides (about 100 A. D.) speaks of lead poisoning, whilst Pliny[5] not only states that lead poisoning was known in his day, but that the workers in lead and mercury products tied up their faces in loose bags lest they should inhale the pernicious dust.

Raphael, Correggio, and Michael Angelo are stated to have suffered from lead poisoning. Ramazzini[6] in 1713 discusses very fully the sickness of painters, etc., through contact with lead materials.

Probably the earliest English record of lead poisoning amongst white lead workers is that of Sir Philiberto Vernatti[7], who, in a paper, "A Relation of the Making of Ceruse," describes the method of manufacture in use by the Venetians. In addition to describing the details of manufacture, he records the symptoms of lead poisoning, stating.

"The Accidents to the workmen are, immediate pain in the Stomack, with exceeding contortions in the Guts, and Costiveness that yields not to Cathartick's, hardly to often repeated Clysters: beat to lenitives, Oil of Olives, or strong new Wort. It brings them also to acute fevers, and great Asthma's or shortness of breath. And these we find effected principally by the mineral steams in the casting of the plates of lead, and by the dust of the flakes. Also by the steams coming from out of the heaps when the pots are raking up.

"Next, a vertigo, or dizziness in the head, with continual great pain in the brows, blindness, stupidity, and paralytick affections, loss of appetite, sickness, and frequent vomitings, generally of sincere phlegm, sometimes mixed with choler, to the extreamest weakning of the body. And these chiefly that have the charge of grinding, and over the drying place."

A remarkably comprehensive survey and one capable of being applied to practice of today.

It was not until 1891 that the English Government actively investigated the question of lead poisoning in white lead works, and since then very satisfactory results have been obtained.

Taking the official figures supplied by the Home Office (representing the period during which notification of lead poisoning in white lead works has been made compulsory) we find that a remarkable improvement has been effected in the health of the workers. This satisfactory result is due to the hearty co-operation of the Home Office officials and the manufacturers. During the past 15 years manufacturers have spent over £80,000 on alterations and dust removal plant, in order to render more healthy the condifions of employment[8].

Briefly, the protective measures adopted are as follows:

(1) Education of workers to a true appreciation of the dangers to which they are subjected.

(2) Provision of overalls, adequate washing appliances, and baths, respirators, medical supervision, and nourishment.

(3) Exercise of care in selection of workers, having due regard to the problem of natural predisposition, general habits and alcoholism.

(4) Elaborate precautions for the prevention of dust, with minimum personal handling of dry lead products.

The foregoing have been carried into effect as follows:

Education of Worker.—By means of pamphlet stating in clear and simple language the poisonous nature of all lead products, how these may enter the system, what primary effects appear, and what precautions should be taken. The pamphlet is not an elaborate medical treatise, but is worded in plain, blunt English.

Overalls, Washing, Etc.—Each worker is required to wash before meals (in the employer's time), and must bath-

weekly. Overalls are provided and washed weekly. Respirators are used on dusty work, and these are cleansed at least once each shift, or more often if necessary. Medical inspection takes place weekly, but here much depends on the worker, as there is a marked tendency to be secretive in their replies to the queries of the doctor, fearing that preliminary symptoms might prejudice their further employment. Nourishment in the form of cocoa or milk is provided for each worker before starting work, and at meal times. Experience has shown that milk is of the greatest possible value, and this has almost entirely displaced the old-fashioned sulphuric acid drink, which was of questionable value.

Simple medicines such as Epsom salts, castor oil, and sulphur tablets are provided, and in one English works sodium sulphide pills have proved to be very efficient, due to the comparative insolubility of lead sulphide in gastric juices. Incidentally it may be mentioned that Goadby[41] has observed that Italians who are engaged in white lead works seldom contract lead poisoning. It is noteworthy that Italian workers do not drink much beer, eat a lot of rough food and vegetables, and a large quantity of garlic (the sulphur of which appears to be highly beneficial).

Selection of Workers.—This can only be a gradual process. A worker can never be judged by his face value as a lead worker. Medical inspection weeds out the obviously unhealthy and undesirable employes, but gives no positive indication of suitability. It is only by careful observation of the man at work that "dirty" workers can be discovered. This observation is made by a reliable worker of foreman status, who acts as inspector, and instructs the new worker as to the methods of avoiding the creation of dust in his work. The employment of casual labor is dangerous, and should be avoided. Dr. T. M. Legge[42], in the special report of 1898, re white lead works, gives the incidence of lead poisoning amongst casual labor as 39 per cent, against 6 per cent for regular employment.

The home conditions of a man are often a safe guide to his suitability for employment. Good home conditions mean good nourishment and habits.

The efficiency of regulations has been clearly demonstrated by the results obtained both in England and on the continent, and it is quite certain that lead poisoning is amenable to regulations when the sources of trouble can be defined.

Attention has recently been drawn in the public and technical press to a process devised by Clague for the electrolytic removal of lead from the human system, and it is claimed that very striking results have been obtained. Oliver[43] describes the process and method, and states that he has carried out experiments which have proved the value of the process. The method adopted is to immerse the arms and legs of patients in baths of salt solution, and to pass a current of electricity through the baths and patient. Actual removal of lead from the system is claimed, and it is stated that metallic lead is deposited on the electrodes which are in contact with the extremities of the patient. The process purports not only for the removal of lead from those suffering from the disease, but further from those in whose system lead may be present without exerting any apparent ill effects, so that the method might become part of a preventative system. If the results claimed receive confirmation after extended inquiry, then a powerful weapon has been discovered, with which lead poisoning may be readily combated. It must be here stated that Oxley[44] in actual lead works practice has failed to obtain satisfactory results, and the universal efficacy of the process is still to be established.

Before any problem of industrial hygiene can be successfully solved it is necessary that careful statistics should be available. A very striking example of this is brought to light in connection with lead poisoning amongst workers in paints and colors. In 1902 Legge[45] made an analysis of the processes, and found that 72 per cent of the cases of lead poisoning must be ascribed to dusty processes—an observation of fundamental importance, and one which has received emphatic confirmation by the decrease in cases consequent on the introduction of dust removal appliances. Legge[46] in 1909 was able to report a decrease of cases during the preceding ten years, consequent on the introduction of dust removal appliances.

In a recent report of the factory inspector[47], it is stated during the last six years two-thirds of the cases of lead poisoning in East London stack works have occurred amongst men working in stacks where it has not been found possible to apply the principles of exhaust ventilation. To those engaged in the white lead industry this observation is important, and I shall be much mistaken if before long an improvement is not effected in this direction, knowing as I do the difficulties which have been overcome in the past.

It is only within comparatively recent times that lead poisoning has been subjected to strict inquiry on a scientific basis, and the results obtained have been of the greatest importance, not only in respect to the disease itself, but also in clearly defining and determining the relative dangers of the channels of infection.

Goadby[48] is of the opinion that the industrial importance of infection by respiratory tract as against infection per gastro-intestinal tract is to be expressed by the ratio 100:1. In other words, "dust" is the serious source of trouble.

This is a strong argument against the manufacture of dry white lead, and emphasizes the hygienic value of the wet pulping machine previously noted. The general adoption of the "wet pulping" method would be beneficial to all concerned, and is worthy of the attention of those concerned with the handling of dry white lead.

I add a list of works dealing with the hygienic phase of lead work in the hope that it may be of value for reference.

It is impossible for me here to discuss the use of white lead, and I must content myself with a passing reference to a recent phase of the subject which has led to considerable discussion recently. You are aware that since February, 1911, a Departmental Committee of the Home Office has been sitting to consider the use of lead products by painters. The report of this committee is awaited with a considerable amount of interest.

In the meantime some very wordy battles have been waged between the partisans of white lead and substitutes. I fear that much time has been wasted and little real progress made. Prohibition has been lightly talked of, without any consideration as to the far-reaching effect of such an act, even assuming that statistical evidence was available showing that the sickness rate amongst painters was so high as to suggest that it had become expedient to consider such an action. In point of fact, no such evidence is as yet available in this country.

To my mind prohibition of the use of white lead is a tacit admission of inability to deal with the problem of ordinary industrial hygiene. Prohibition is an effective, grossly unfair method of dealing with any problem of an unknown character, which, if applied logically, would undoubtedly be the most serious barrier to industrial progress which has ever yet been devised.

It is obvious that a white lead worker handles in the course of a day at least as much white lead as is handled by the average painter in a year, and it is clear the risk of white-lead workers is much more intense than that of the painter.

The previously quoted figures show with what success reasonable regulations have reduced the poisoning in white lead works, and it is only reasonable to suppose that the same success would attend the application of regulations to those engaged in the use of white lead.

There is real need in this country for investigation as to the respective merits and demerits of various paints, and I believe that makers generally would welcome such an

inquiry. In the United States of America extensive trials have been undertaken[25], and much information has been obtained, but unfortunately we are unable to apply their results in this country owing to different climatic conditions, although doubtless their experiences will be of extreme value as indicating the lines on which experiments should take place, and Mr. H. A. Gardner, of the Institute of Industrial Research at Washington, has kindly offered to give the advantage of his experience if similar inquiries were undertaken in this country.

In conclusion, I desire to state that it has been necessary for me to draw largely on the publications of others in the preparation of this paper, and to all whose works I have consulted I beg to make acknowledgment. It is impossible to give names in detail, and I append a bibliography of works bearing on many of the points with which I have dealt so that originals may be consulted.

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Paint Notes From Kansas City

Settlement of McDonald Company's Difficulties is Expected

(Special to the REVIEW.)
Kansas City, Mo., December 24, 1913.

Prospects for an amicable settlement of the financial difficulties of the McDonald Paint & Glass Company, of Kansas City, are growing brighter steadily, according to a recent announcement by President W. M. McDonald. Settlement is being effected with many of the creditors, while the offer made by the company is being considered by others. Prospects are that the storm will be weathered and that the pioneer house will regain its former footing as one of the leading paint companies of Kansas City in the very near future.

Kansas City was deserted by many paint men for the holidays. A number of the members of the trade have warm spots in their hearts for other cities and took advantage of the opportunity to spend a few days in the midst of friends. M. E. Jacobs, assistant manager of the Pittsburgh Plate Glass Company, and secretary of the Kansas City Paint, Oil and Varnish Club, spent the holidays at his old home in St. Louis. C. R. Cook, head of the paint company of that name, went to Milwaukee, Wis., and H. S. Lynn, sales manager of the Seidlitz Varnish Company, spent the festive season with his daughters at Peoria, Ill.

Meetings of the Kansas City Point, Oil and Varnish Club, suspended for the holidays, will be resumed early in January. The club will continue to meet at luncheon every Tuesday at one of the Kansas City hostelries.

Damages of $4,000 were awarded Joseph M. Higgins, a plumber, against the Devoe-Raynolds Paint Company recently for personal damage injuries said to have been sustained by him. The case probably will be appealed. Higgins alleged the janitor turned on the steam while he was repairing a pipe, severe scalds resulting.

Rumors to the effect that the Santa Fe railroad would close down its coach paint shop at Topeka, Kan., for the winter, are unfounded, according to an announcement by officers of the road. The shop, employing several hundred men, was closed down for one day, because of the heavy Christmas travel, but already has re-opened, and will continue to be a heavy consumer of paint during the winter.

The C. R. Cook Paint Company, which recently took over the old A. M. Hughes Paint & Glass Company, will discontinue the retail establishment at 1213 Walnut street, Kansas City. A closing out sale was staged during the holidays, with splendid results.