U. S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
CHAS. P. NEILL, Commissioner

BULLETIN OF THE UNITED STATES BUREAU OF LABOR STATISTICS . . . WHOLE NUMBER 120

INDUSTRIAL ACCIDENTS AND HYGIENE SERIES: No. 2

HYGIENE OF THE PAINTERS' TRADE

MAY 13, 1913

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

CONTENTS.

BULLETIN OF THE

U. S. BUREAU OF LABOR STATISTICS.

WHOLE NO. 120. WASHINGTON. MAY 13, 1913.

HYGIENE OF THE PAINTERS' TRADE.

BY ALICE HAMILTON, M. A., M. D.

INTRODUCTION.

It is absolutely impossible to discover even approximately the proportion of painters in the United States who suffer injury from the use of lead paint. In the first place, we do not know how many painters there are who are exposed to this danger. The United States Census for 1900 gives 277,541 painters, glaziers, and varnishers, but since the latter two classes of workmen are not exposed to lead paint this enumeration is valueless for our purpose. The Brotherhood of Painters, Decorators, and Paper Hangers also includes too many classes of workmen for their figures to be of use even for the organized branch of the trade, and of course they do not include the nonunion men.[1] It is unnecessary to say that the sources of information as to lead poisoning among painters are even less trustworthy. This study is presented, therefore, as a tentative report only, a collection of what can be gleaned from the scanty sources available. In every case where a statement is made, care will be taken to explain upon what foundations it rests and how nearly accurate it may be assumed to be.

This is the most widespread of the lead-using trades, even more general in its distribution than printing or plumbing, for it is safe to say that there is no community so small that it does not include at least one painter.

The industry falls naturally into divisions based more upon economic grounds than upon any other. Broadly speaking, we have two classes: First, the independent house and sign painters, working now for one contractor, now for another, under conditions that vary greatly, and using at different times paints of widely differing formulas and applying them in different ways, according to the ideas of the

[1] There are 72,500 members of the Brotherhood in the United States.

contractor under whom they work and the cheapness or expensiveness of the work contracted for. Their employment is largely seasonal and they have long periods of unemployment,[1] but to offset in part this disadvantage they are, in most large cities at least, members of a strong labor organization with power to influence in great measure their hours of work and the conditions under which the work is done. House painting is a skilled trade, requiring an apprenticeship of three years, and sign painting an apprenticeship of four years, and these painters are usually much above the average of wage earners in intelligence and education.

Between this and the next class come the ship painters, whose work resembles house painting very closely, yet, owing partly to the fact that the trade is unorganized, partly to differences in the work itself, ship painting must be considered separately. The shipyards employ union men, but maintain an open-shop policy.

The other large class comprises painters who work in manufacturing plants, factories, or workshops of any kind. This class of men has much steadier employment both as regards time and character of work than the house painters. They use the same kind of paints and the same methods day after day, though, as is true of all factory work, subdivision of labor brings it about that a painter often has but one small part of the product intrusted to him, so that his skill is exerted in a very restricted field. In many factories hand painting has been replaced by machinery, which dips the objects to be painted in large tanks of paint and then swings them out over a drip board to dry. In other factories the paint is sprayed on by means of compressed-air atomizers. Consequently much of the work can be done by unskilled or semiskilled men, and many newly arrived immigrants with no experience in anything but farm work are at present employed in factory painting.

This class of painters is not organized,[2] yet union painters may take employment in open shops, such as railway-coach, carriage, and automobile factories, and it is not uncommon to find skilled union painters employed at the better-paid, more difficult parts of the work, while unskilled, nonunion men are employed at the simpler parts. No house painter can work for any length of time without being obliged to employ lead paint to some extent, but in factory work a painter may use leadless paints entirely. It follows that some classes of factory work are safer than house painting can be, while it is also probably true that some of the most dangerous kind of work in the

[1] The answers given by 1,388 men belonging to the Painters District Council No. 14, Chicago, in 1911 showed that eight weeks and two days was the average of unemployment during the year (see p. 49.) It is said to be somewhat less for sign painters.

[2] There is a trade-union of carriage and automobile painters, but it does not control the industry.

painters' trade is to be found in factories. These painters come under the following heads:

Coach painters:
- Wagons and carriages.
- Automobiles.
- Railway and street-railway coaches.

Bridge, tank, and structural iron painters.

Agricultural implements.

Furniture, picture frames, moldings.

There have been changes of late years tending to increase the number of painters in some industries and to lessen the number in others. In cities where brick, cement, and stone have displaced wood for the construction of buildings, the decrease of painters employed on exterior work has been compensated for by the increase in demand for interior painting. The French and colonial styles of interior decoration, so popular now, require painting where varnishing and staining was the rule not many years ago. There has also been an enormous increase in automobile painting, and there has been an increase in the output of agricultural machinery. On the other hand, there is much less painting of furniture than there used to be, and there is an increased use of machinery in factories making agricultural implements, wagons, and automobiles which lessens the number of painters employed, for a few men dipping take the place of many formerly employed in handwork.

COMPOSITION OF PAINT.

In the following discussion of the different constituents which enter into the composition of paints, no consideration is given to any aspect of the question except the hygienic. Pigments and liquid vehicles and driers and the methods of applying them are discussed only with regard to their effect upon the health of the men who handle them, without any consideration of the excellence or inferiority of the product. The paint which is worst in point of covering power and permanence may be the one least fraught with risk to the workman, but it is the latter aspect only which is discussed here.

A paint is a mixture of pigment and vehicle (liquid portion) either of which may be harmless or poisonous. Usually there is at least one substance in paint which is capable of producing harmful effects on the workmen who handle it; often there are several of such substances. High-priced paints usually consist of white lead, linseed oil, and turpentine, the first and last of which are poisons. Cheap paints may contain as pigments nothing more dangerous than chalk or barytes, but the liquid portion may be so strong in petroleum products as to cause acute poisoning among men who are obliged to use the paint in small ill-ventilated inclosures.

A good paint is made by grinding pigments in linseed oil and since the raw oil dries very slowly a so-called drier is added. Oil driers are made by heating linseed oil with an oxidizing agent, manganese dioxide, or the oxides of lead, to which is added a volatile oil such as petroleum spirits or benzine. Japan driers contain gums or resins and are used in quick-drying paints. Turpentine is added in varying proportions, a larger amount for paint used on interior work than for paint which is to be used outside and exposed to the weather. A typical formula for paint that is to be used outside is the following:

	Per cent.
Pigment	63
Liquid	37
Liquid.	
Linseed oil	86.0
Japan drier (44 per cent solid, 56 per cent volatile)	5.5
Turpentine	5.5
Petroleum spirits	3.0

A typical formula for paint for interior work calls for less linseed oil, because of the tendency of this oil to turn yellow, and contains more turpentine.

	Per cent.
Pigment	60
Liquid	40
Liquid.	
Linseed oil	35
Turpentine	39
Japan drier (see formula above)	13
Petroleum spirits	12

However, in cheaper paints the oil and also the turpentine may be largely displaced by petroleum spirits.

Gloss paint has varnish added and a relatively large proportion of oil; flat paint, less oil and more turpentine, but in cheap flat paints benzine takes the place of most of the turpentine. In cheap gloss paints, also, the amount of benzine is larger, the oil being supplemented by melted rosin, which is mixed with a little linseed oil and then reduced to the required thinness with benzine. On the whole, it may be said that the cheaper the paint the less danger there is from poisonous pigments and the greater the danger from volatile poisons in the liquid vehicle. An exception to this rule is the use of paints very rich in turpentine, as, for instance, in the painting of the cabins of ships, where the last coat consists of zinc white and white lead in a vehicle that is almost pure turpentine.

Other volatile substances with which the painter may come in contact more or less are benzole, amyl acetate, acetone, and wood alcohol.

PHYSIOLOGICAL EFFECTS PRODUCED BY LIQUID CONSTITUENTS OF PAINT.

LINSEED OIL.

It has long been believed that surfaces freshly painted with white lead in linseed oil give off fumes or emanations which may cause more or less distressing symptoms to the painters and still more to the inhabitants of freshly painted rooms who are not accustomed to these fumes. Among the symptoms described are headache, dizziness, nausea, intestinal pain, vomiting, diarrhea. Such cases have been reported as caused by lead poisoning, and physicians have insisted that their occurrence proved the presence of lead in the emanations from fresh lead and oil paint. Oliver[1] speaks of an outbreak of colic among the sailors on a French man-of-war which was traced to the fumes from fresh lead paint.

In the Pasteur institute experiments were made under the direction of Trillat which showed that fumes from white lead paint are capable of hindering the growth of vegetable molds. This was not found to be true of zinc oxide paint nor of dry white lead nor of turpentine. The harmful fumes arose from white lead paint only and were the result of the mixture of oil and white lead.

Similarly, E. C. Baly, F. R. S.,[2] finds that certain emanations are given off from surfaces painted with white lead and oil, which can not be obtained from white lead alone, nor oil nor turpentine alone, emanations which may give rise to the symptoms described above. However, Baly insists that the fumes in question do not contain lead in any form, but consist of an aldehyde. He made spectroscopic absorption tests with (1) a mixture of linseed oil and white lead, (2) linseed oil and zinc white, and (3) linseed oil and basic lead sulphate, and he found absorption bands from the white lead mixture only, showing that some volatile substance was given off from white lead and linseed oil but not from the other mixtures. Dry white lead gave no absorption bands. He found that this gaseous product would cause symptoms like those which have sometimes been interpreted as due to lead poisoning but that no lead could be demonstrated in it. One would not expect that quickly developing symptoms would follow the inhaling of finely divided lead salts, for all clinicians and experimenters know that lead is fairly slow in producing its poisonous effects.

After finding that these same absorption bands could be obtained with lead hydroxide and that the volatile substance was an unsaturated compound of great reducing power, Baly concludes that it is in all probability an aldehyde. The addition of turpentine increases the production of this aldehyde. If these experiments are con-

[1] Bulletin of the United States Bureau of Labor, No. 95, p. 21.
[2] Journal Soc. Chem. Indust., 1912, Vol. xxxi, p. 515.

firmed, we shall have to regard the symptoms experienced by persons who sleep in rooms freshly painted with white lead linseed oil paint as caused by a transient poisoning from aldehyde fumes, not as lead poisoning.[1]

TURPENTINE.

Of the liquid constituents of paint, next in importance to the linseed oil comes turpentine, used as a thinner and also for its drying properties. Oil or spirits of turpentine is produced by the distillation of gum from pine trees. It absorbs oxygen, forming a resinous body, and this process is hastened by the presence of lead oxide. The odor of turpentine is distinctive, and all experienced painters know when they are working with a paint containing it. A new turpentine has lately come into use, called wood turpentine, which is obtained by the destructive distillation of pine wood and which has a much more disagreeable tarry odor and does not evaporate as quickly as gum turpentine. Whether or not the physiological effects are different from those of gum turpentine is not known as yet, though painters who have used it say that the odor is nauseating and they object very much to working with it. House and ship painters are exposed to turpentine fumes often and for long periods of time, for turpentine is a constituent of varnish as well as of paint.

R. von Jaksch[2] gives as the symptoms which occur in men working for hours in turpentine-laden air, the following: Headache, dizziness, dry throat, frequent cough, indications of bronchitis, and irritation of the urinary system, as shown especially by strangury and by bloody urine. Turpentine is excreted largely by the kidneys, and there may be severe pain in the region of the kidneys. Nervous effects are sometimes produced, excitement, staggering gait, convulsive movements, or even loss of consciousness. There may be inflammations of the skin of various kinds. Chronic nephritis and chronic cystitis not infrequently result from long exposure to these fumes. E. Schäfer[3] reports a case of fatal poisoning from turpentine vapor.

In the report of the Commission on Occupational Diseases of the State of Illinois, in 1911, there is a section on turpentine poisoning. The investigators (E. R. Hayhurst, M. D.; T. E. Flynn, M. D.; and R. H. Nicholls) made a detailed examination of 62 painters and varnishers in Chicago. They tried to select older workmen who had been employed chiefly in indoor work, and to rule out as far as possible all cases of lead poisoning. The men were between the

[1] It is well to remember that Baly's experiments were made with pure linseed oil and white lead, while a paint in actual use for interior work would not be likely to contain more than 35 per cent of linseed oil.

[2] Die Vergiftungen, Wien u. Leipzig, 1910, p. 405.

[3] Germany, Reichsamt des Innern. Jahresberichte der Gewerbe-Aufsichtsbeamten und Bergbehörden, 1909. Berlin, 1910, Bd. III, pt. 25, p. 19.

ages of 24 and 64 years, all but 17 being under 45 years, and all but 15 having worked more than 10 years. Most of these 62 men stated that they had suffered more or less frequently from drowsiness, headache, nausea, loss of appetite, and even vomiting and dizziness while working with turpentine. Fifty-four had suffered from bladder trouble at times, 18 of them having been under medical treatment for kidney and bladder trouble. Twenty-one had had inflammation of the eyes. Fourteen complained of irritation of the throat and lungs, and 7 of skin troubles. A careful examination was made of 44 to determine the presence of kidney disease, and 14 of them, or 31.8 per cent, proved to have organic kidney disease.

It is not possible to determine positively how much the turpentine vapor had to do with these conditions, but it can not be doubted that it is a fairly frequent cause of inflammation of the bladder and less frequently of the kidneys. Ship painters suffer more from turpentine fumes than do house painters, owing to the small unventilated spaces in which they often have to work, and to the large quantities of turpentine used in the work.

PETROLEUM SPIRITS, BENZINE, AND NAPHTHA.

These are trade names given to the heavier distillation products of petroleum, with a boiling point between 220° and 300° F. They are used in high-class paints in combination with turpentine as driers, but in cheap paints they may form the greater part of the vehicle, displacing almost entirely linseed oil and turpentine. The proportion of volatile drier in the total liquid content of a paint should not be over 4 to 7 per cent,[1] but cheap paints may contain as much as 40.78 per cent. The petroleum derivatives are used for many other purposes by painters. They are important constituents of varnish and of paint and varnish removers, usually combined in the latter with more powerful solvents such as benzole, acetone, and wood alcohol. When a wall is to be calcimined the plaster must first be covered with some gummy material to prevent suction, to prevent the calcimine from soaking in. Different sizes are used for this purpose; an oil-paint size, or one made of glue, or a varnish size. This last is a mixture of hard gum, oil, and turpentine thinned with benzine. The painters call it "hard oil," and practically all of them complain of the discomfort they experience from benzine vapors when they are "hard oiling."

Symptoms caused by benzine vapors in workmen have been described by several German writers,[2] who note the increasing number

[1] E. C. Ladd and C. D. Holley, in Bulletin No. 70, North Dakota Agricultural College, Government station.

[2] Zeitschrift für Gewerbehygiene, Wien, 1907. Vol. 14, p. 157. Berthenson, Deutsche Vierteljahrsschrift für öffentliche Gesundheitspflege, Braunschweig, 1898. Vol. 30, p. 315.

of cases of industrial poisoning from the use of these substances in recent years. The nervous system is the one most affected, for these compounds have a special affinity for certain elements of nerve tissue. There is a sense of pressure in the head, singing or roaring in the ears, headache, sense of confusion, dizziness, inability to do fine work, and a loss of muscular strength. The symptoms may be much like those of alcoholic intoxication, staggering, clouding of the memory, even hallucinations of sight and hearing. The next morning the benzine-poisoned painter feels as if he were recovering from a fit of drunkenness. A very large dose of naphtha or benzine fumes, as would result from working in a small ill-ventilated place, has been known to cause labored respiration, rapid pulse, collapse with complete unconsciousness, and, more rarely, convulsions. Chronic poisoning gives rise to disturbed digestion, chronic bronchitis, nervousness, excitability, trembling muscles, loss of strength, and even impaired mentality. There are also chronic skin troubles, caused by benzine and naphtha.[1]

Petroleum, coal tar, is used in combination with rosin and asphalt in the so-called bituminous composition, used for painting the water bottoms of ships and for bridges and railway water tanks. This paint must be applied hot, and it gives off thick fumes which are very irritating to the mucous membrane and to the eyes and cause nausea, headache, and symptoms of intoxication. Skin diseases, acne, ulcerations, etc., are said to be more frequent in workers with petroleum than in workers with benzine and naphtha. Crude petroleum contains sulphur compounds which increase its poisonous qualities.

BENZOLE.

Commercial benzole is a mixture of hydrocarbons containing about 40 per cent of benzene (C_6H_6), a very volatile liquid which has powerful solvent properties and penetrates deeply. On this account it is used in primers on hardwoods, but it can not be used in finishing coats because it would act as a paint remover, it is so strong a solvent. Benzole is considered the best substance for paint and varnish removing.

Because of its increasing use in many manufacturing processes, there has been a good deal written of late, especially in Germany, on the poisonous effects of the vapors of benzole or benzene,[2] and the Germans distinguish clearly between poisoning from this substance and poisoning from benzine, which is less volatile and less dangerous. Von Jaksch[3] says that the inhalation of benzole fumes may be rapidly

[1] R. von Jaksch, Die Vergiftungen. Wien u. Leipzig, 1910.
[2] Lewin, Münchener medizinische Wochenschrift, München, 1907, vol. 54, p. 2377.
[3] Idem.

fatal and quotes a case reported by Beinhauer [1] in which there were changes found in the blood, a solution of the red blood corpuscles, hemorrhages into the organs and mucous membranes, and parenchymatous degeneration of the organs. The symptoms of acute benzole poisoning are headache, dizziness, a flushed face followed by cyanosis, nervous excitement (like that caused by alcohol), hallucinations, delirium, or coma. In chronic cases there is inflammation and ulceration of the gums and lips, as in scurvy.

WOOD ALCOHOL OR METHYL ALCOHOL.

The greater number of victims of wood-alcohol poisoning have drunk the poison with adulterated whisky, but since the introduction of wood alcohol for industrial purposes there has been an increasing number of cases reported in which the poisoning has taken place through the lungs by the inhalation of fumes. These men have been chiefly varnishers, using shellac or varnish.[2] The symptoms are hoarseness, headache, ringing in the ears, trembling, difficult breathing, nausea, convulsive twitching of the muscles, impairment of sight, a mist or veil before the eyes; severe cases suffer from weakness of the heart, delirium, coma, and after consciousness is regained more or less complete blindness.[3] This impairment of the sight is characteristic of wood-alcohol poisoning and makes this the most serious poison the varnisher and painter have to deal with. Fortunately, during the last two years it has been largely displaced by denatured alcohol.

AMYL ACETATE.

What the painters call "banana oil" is usually a mixture of amyl acetate, acetone, and benzine. Amyl acetate is a derivative of fusel oil and acetic acid and is used in varnishes, in bronzing, silvering and gilding fluids and in paint and varnish removers, as it is a very powerful solvent for gums of all kinds. The fumes are narcotic, causing headache, giddiness, confusion, drowsiness, nausea, and disturbed digestion, palpitation of the heart, and difficulty in breathing.[4]

ACETONE.

Acetone ($(CH_3)_2CO$) is also a strong solvent of gums and resins and therefore used in much the same way as amyl acetate. There is nothing to be found in the literature as to the toxic properties of this substance.

---

[1] Lewin, Münchener medizinische Wochenschrift, München, 1896, vol. 43, p. 915.
[2] Casey Wood, Journal American Medical Association, Chicago, 1912, vol. 2.
[3] R. von Jaksch, Die Vergiftungen. Wien u. Leipzig, 1910, p. 277.
[4] Th. Sommerfeld, Bulletin of United States Bureau of Labor, No. 100.

CARBON DISULPHIDE.

This very powerful poison, which causes serious damage to the red blood corpuscles and to the nervous system, is mentioned in a recent German publication [1] as a new ingredient in certain quickly drying paints. In this country the use of this dangerous substance has not yet passed the experimental stage, except that it is employed to a slight extent in metal polishes.

CORROSIVE POISONS.

It was formerly necessary for painters to handle strong bleaching fluids in preparing surfaces of wood and metal, but these have been gradually abandoned, and carbolic acid and oxalic acid and potash are not used to nearly the same extent now as a few years ago. These are all corrosive poisons, and when they come in contact with the skin they cause a spreading inflammation, with painful and slowly healing ulcers. The painters have always objected very much to their use, and it is largely on account of this that these bleaching agents have been gradually discarded.

FLAT-FINISH PAINTS.

At present there are on the market numbers of quick-drying "dull-coat" or "flat-finish" paints which are comparatively cheap, easily applied, and require no rubbing. As a usual thing these paints are leadless, the pigment consisting of zinc white or lithopone or the cheaper inert pigments. There is, however, a quick-drying white-lead paint made for carriages and railway cars. The Germans have already called attention to the dangers of these new paints and point out the fact that rapid drying means a large quantity of volatile substance in the paint, and this substance is always one of the petroleum products, with a varying proportion of turpentine. Grotjahn and Kaup [2] speak of the possibility of fatal poisoning as a result of working with quick-drying paints in small unventilated inclosures, and E. Schaefer [3] utters the same warning. If, however, the paint can be applied in well-ventilated rooms there is practically no danger attended with its use; and the introduction of a leadless paint for interior work marks a great step forward in the hygiene of this industry.

PHYSIOLOGICAL EFFECTS.

In December, 1912, Dr. John H. Landis, health officer of the city of Cincinnati, reported to the Bureau of Labor Statistics that a number of painters had complained to him of various distressing symp-

[1] E. Schaefer, Germany, Reichsamt des Innern. Jahresberichte der Gewerbe-Aufsichtsbeamten und Bergbehörden, 1909. Berlin, 1910, Bd. III, pt. 25, p. 20.
[2] Handwörterbuch d. sozialen Hygiene. Separatabdruck, 1912, Leipzig.
[3] Loc. cit.

toms which were caused by the use of certain brands of flat-finish dull surface paints in interior work when the ventilation was very faulty. Dr. Landis requested that an inquiry be made by the Bureau to ascertain the substance or substances in these paints which were responsible for the disorders complained of, and in pursuance of this an investigation was made in Cincinnati in the course of which nine painters were interviewed, all of whom had had much experience with this kind of paint. These men were members of the Brotherhood of Painters and Decorators and were very intelligent men, able to give a clear and detailed history of their experience to the examining physicians. Their histories may be condensed as follows:

After a longer or shorter period of employment with the paint in question, a period usually of two or three days, dependent on the closeness of the room in which the work was done, the man would begin to suffer from dizziness, headache, spots before the eyes, dryness and choking feeling in the throat, burning of the eyelids. Appetite was always interfered with and six of the nine complained of nausea, four of frequent vomiting. Pain of a colicky character was felt in the region of the navel in five cases, along the margin of the ribs in three, and in the lumbar region in three. One man suffered from ulcers on the lips and gums. In the morning there would be a feeling of "dopiness;" sleep had brought no refreshment, and the man felt as if he had worked all night. Constipation was not common, but more or less strangury and painful urination was complained of by five men. One man who had used the paint for two years had suffered severely from bladder trouble, resulting in a chronic cystitis. Three years before he had been accepted by a life insurance company, but at this time he had just been rejected for a second policy because he was found to have albuminuria. A cystoscopic examination showed catarrhal cystitis.

Disturbances of sight (transient always) occurred in six of the nine men. Usually the man described it as a veil or cloud before the eyes, sometimes as floating spots.

Some of the men said that toward the end of the day they could no longer do the finer work, partly because of dizziness, partly because of impaired sight. One man fell from the scaffold because "everything went black before his eyes," another began to stagger and had to be half carried out into the open air, while another was blinded and had to be led out of the room. In some cases, curiously enough, the weakness, nausea, and dizziness were felt when the man first got out into the fresh air. One man said that he always would stagger then, though he could walk steadily inside.

It was evident that the substance which gave rise to these symptoms was not any compound of lead, or indeed any part of the pigment content of the paint, but a volatile constituent, with a special affinity for the central nervous system. This was shown not only by the character of the symptoms, but by the rapidity of their development and the fact that they subsided to a large extent in the fresh air. The men stated that the paints dried very rapidly, and that air must be excluded from the room as much as possible lest the drying take place so quickly that by the time the painter had reached the bottom of the wall he would find that the edge of the paint at the top had begun to dry, and a streak would show between it and the fresh paint applied next to it. Any draft of air would turn streaky the fresh paint. The worst trouble was experienced by some men who were employed on a big cheap apartment house. Each apartment had a tiny kitchen with no outside windows and the walls were painted with this dull-finish paint. The men could work only two hours at a time; then they were obliged to go out on the fire escape for an hour to get rid of the headache, dizziness and choking, and the smarting and watering of the eyes. On a damp, heavy day the evils of the work were all accentuated.

ANALYSIS OF SAMPLES OF FLAT-FINISH PAINTS.

Samples of two of these paints were analyzed by the Bureau of Standards, and the reports of the analyses as given below show that there is nothing poisonous in the pigments, but that there is an excessive amount of volatile thinner, in this case benzine with turpentine.

REPORT OF UNITED STATES BUREAU OF STANDARDS ON CHEMICAL ANALYSIS OF PAINT.

Flat-finish paint No. 1.

PAINT.

	Per cent.
Pigment	60.7
Oil	10.1
Volatile	29.2

PIGMENT.

Analysis.	Per cent.	*Probable composition.*	Per cent.
Oxides of iron and aluminum	0.3	Oxides of iron and aluminum	0.3
Zinc oxide	31.8	Zinc sulphide	9.3
Lime	13.2	Zinc oxide	24.0
Magnesia	.9	Calcium carbonate	22.1
Carbon dioxide	10.7	Magnesia carbonate	1.8
Sulphuric anhydride	.4	Calcium sulphate	1.0
Sulphur	3.1	Barium sulphate	25.1
Insoluble	41.3	Magnesia silicate	16.2

Pigment is lithopone with excess of zinc oxide, calcium carbonate, and magnesia silicate.

OIL.—Resin not detected.

VOLATILE.—Sp. gr. at 15.5° C. (59.9° F.), 0.785; refractive index at 20° C. (68° F.), 1.437. Tests indicate that the volatile is benzine with about 20 per cent turpentine. Film dries in about 35 minutes, and after 24 hours at 105° C. (221° F.), it is hard and fairly elastic.

Flat-finish paint No. 2.

PAINT.

	Per cent.
Pigment	67.7
Oil	10.3
Volatile	22.0

PIGMENT.

Analysis.	Per cent.	*Probable composition.*	Per cent.
Oxides of iron and aluminum	0.7	Oxides of iron and aluminum	0.7
Lead oxide	.1	Zinc sulphide	20.2
Zinc oxide	19.3	Zinc oxide	2.5
Lime	.5	Lead oxide	.1
Magnesia	4.4	Calcium sulphate	1.0
Carbon dioxide	2.5	Basic magnesia carbonate	7.8
Sulphuric anhydride	.4	Barium sulphate	53.5
Sulphur	6.7	Magnesia silicate	14.2
Insoluble	67.7		

Pigment is lithopone with a trace of lead and considerable magnesia carbonate and silicate.

OIL.—Resin not detected.

VOLATILE.—Sp. gr. at 15.5° C. (59.9° F.), 0.784; refractive index at 20° C. (68° F.), 1.436. Tests indicate that the volatile is benzine with about 20 per cent turpentine. Film dries in about 45 minutes, and after 24 hours at 105° C. (221° F.), it is hard and fairly elastic.

The part of this analysis that interests us is the liquid vehicle, as the pigment is harmless. The ingredients in the vehicle—oil, turpentine, and benzine—are the same as those found in lead paints, but the proportions in which they are mixed are quite different from those in the typical formula given on page 8. The formula for interior paint given there calls for 35 per cent of oil, 39 per cent of turpentine, and only 12 per cent of petroleum spirits. In these flat-finish paints the proportions in the vehicle are as follows: No. 1, oil 25.7 per cent, volatile liquid 74.3 per cent, of which 14.9 per cent is turpentine and 59.4 per cent benzine. For No. 2, oil 31.9 per cent, volatile liquid 68.1 per cent, of which 13.6 per cent is turpentine and 54.5 per cent benzine. This enormous proportion of benzine explains why the paint dries so rapidly and why currents of air must be excluded from the room which is being painted. It is clear that these painters were suffering from symptoms of acute benzine poisoning, complicated in one case at least with chronic turpentine poisoning.

PIGMENTS.

The only pigments which concern us in this study are the lead salts, namely (1) white lead, or basic carbonate of lead (approximately, 2 $PbCO_3(OH)_2$); (2) sublimed white lead, or basic lead sulphate (approximately 2 PbSO 2 PbO, the proportion of oxide being variable); (3) red lead and orange mineral (Pb_3O_4, or $2PbO - PbO_2$); (4) chrome yellow, or lead chromate ($PbCrO_4$); (5) chrome green, or Brunswick or Prussian green, a mixture of yellow chromate with Prussian blue. Of these, the first has by far the most general use, expecially for exterior work. Lead sulphate (sublimed white lead or basic lead sulphate) has come into increasing use of late years, sometimes as a substitute for white lead, sometimes in combination with the latter. There are, of course, many paints on the market which are supposed to contain white lead, but which are really made up of cheaper leadless substitutes. The law of North Dakota requires that all paint sold in that State be clearly labeled with the ingredients it contains, and similar "pure paint" laws to protect the buyer are now in force in Wisconsin, Iowa, Minnesota, Nebraska, Vermont, and bills are pending in Pennsylvania and Ohio.

Red lead has long been held to be the best paint for metals on account of its elasticity and rust-preventing properties. Objections to the use of red lead are based on its expensiveness and the fact that it is troublesome to use. When mixed with linseed oil it settles and cakes in a short time so that it can not be put on the market ready for use, but must be mixed fresh by the painter every day or so. At present there are red lead paints prepared with the addition of lighter inert substances which prevent the settling; nevertheless red lead is being largely displaced by carbon paint, graphite, iron oxides, chromatized paints, and coal tar paints for covering metallic surfaces, such as structural iron, bridges, water tanks, gas tanks, etc. On certain parts of structural iron and of bridges and railway cars, red lead is still considered essential by most contractors, but for the painting of agricultural implements it has quite given way to the cheap German para reds. Orange mineral is used largely in wagon painting.

There is not nearly as much demand for chrome yellow as formerly, aniline colors and ochres being used instead. It is still used for tinting in house painting and on farm wagons and railway coaches. Chrome green still holds its own as a paint for window shutters.

RELATIVE POISONOUSNESS OF THE DIFFERENT LEAD COMPOUNDS.

There has been much dispute among scientists as to the relative poisonousness of the different lead salts. For a long time it was assumed that the more readily a lead compound dissolved in dilute

hydrochloric acid (the degree of dilution being about the same as that in human gastric juice) the more poisonous it was. Then Blum's experiments seemed to show that the action of gastric juice is different from that of a simple solution of hydrochloric acid and that animals can be poisoned by feeding on lead salts which are almost insoluble in dilute hydrochloric acid.[1] The presence of a little peptone (the product of gastric digestion of albuminous food) was found to favor the solution of these salts. Leymann,[2] therefore, classifies the poisonous lead salts according to the degree of solubility in gastric juice although, he adds, other things being equal a compound is dangerous in proportion to its dustiness.

Among the more commonly used lead salts many would class as the most poisonous the basic carbonate (what we know as "corroded white lead," or "Old Dutch process," or "Carter process," or "precipitated white lead"), because it is more soluble in the gastric juice than red lead, but others would place red lead first because it is lighter and more fluffy. In the dry state (mixing paint or sandpapering or chipping off old paint) red lead is probably more dangerous than white lead, but as a paint the reverse is probably true. The yellow chromate was long considered fairly harmless and factory rules applying to white lead and red lead were not made to cover the use of the chromate either in England or Germany. Then K. B. Lehmann[3] tested this salt on animals and as a result of his experiments lead chromate is now considered as about on a par with red lead in harmfulness. The sulphate of lead, the basic sulphate or oxysulphate, often called sublimed lead, is beginning to be an important constituent of paint. For a long time it was considered quite harmless, for it is very sparingly soluble in dilute acids. It used to be the practice among English physicians, and still is the practice of some American physicians, to recommend a weak sulphuric acid drink for workmen exposed to lead poisoning, under the impression that this will cause the poisonous lead compounds which enter the stomach to change into the harmless sulphate.

LEAD POISONING IN FACTORIES MAKING SULPHATE OF LEAD.

Advocates of lead sulphate as a substitute for the carbonate have often made very emphatic statements as to the harmlessness of the sulphate, and since the use of the latter is increasing all the time it seemed desirable that careful investigation be made of the poisonous or nonpoisonous nature of lead sulphate when handled in dry form, as a paint, or as a paint dust.

---

[1] Blum, Wiener medizinische Wochenschrift, Wien, 1904. Bd. 54, p. 538.
[2] Bekämpfung der Bleigefahr in der Industrie. Jena, 1908.
[3] Archiv für Hygiene, München und Leipzig, 1892-3. Vol. 16, p. 316.

There are two factories which make sublimed lead, or basic sulphate of lead, and in both of them there is plenty of lead poisoning, because the process is extremely dusty and the men breathe large quantities of finely divided sulphate. In both places the method of obtaining the sulphate is essentially the same. The product is obtained by a sublimation process, the fumes from the furnaces passing through gooseneck flues to end in large dust bags where the finer part collects.

The coarser powder, used in manufacturing rubber, falls into hoppers from the flues, but the finer, which is the basis of paint, has to be shaken out of the bags. Twice in their 8-hour shift the men enter the great bag house where white cotton bags hang in rows like enormous organ pipes, and walking in among them they beat or shake them to dislodge the white sulphate which has collected inside. It is easy to understand what an excessively dusty piece of work this is, and even if a man wears a respirator some of the dust must get in. The sublimed sulphate is very light and fluffy and so full of air that it is difficult to pack down and requires pounding and stamping.

In one of these plants, where 45 to 50 men are employed in the lead-sulphate department, a system of regular medical examinations had been instituted a little while before this investigation was made, and the physicians' records showed that 18 of the sulphate men had been examined recently. Two of them had to be left out of consideration, as they had been employed less than four weeks, but of the remaining 16, 11 showed the lead line on their gums and 5 showed evidence of plumbism, a proportion of almost one to three. In the second plant no records were kept and no information could be obtained from the company doctor, but a search among the employees brought to light 12 recent cases of acute plumbism among the 45 men employed in the sulphate department. Of course this does not include all of the lead-poisoned men, and there is no reason to think that the proportion of men poisoned is lower here than in the first factory.

This shows that lead sulphate is undeniably poisonous, for the amount of lead poisoning in these two sulphate plants is as great as one would expect in a lead-carbonate plant. This does not mean that the sulphate is as poisonous as the carbonate. The work in both these sulphate plants is much dustier than in any part of an old Dutch process factory, except perhaps the dry-pan room of an old-fashioned plant, and it is dust chiefly that causes lead poisoning. The sulphate department bears a bad reputation in both factories, and the men regard the work there as more dangerous than that in any other department, except the litharge and the open hearths. The choking dust is the worst feature. Both plants have washing

facilities for their men, and it is probably true that poisoning takes place through what is breathed in rather than what is carried into the mouth from dirty fingers, although the men say that it is almost impossible to wash the stuff off, it sticks so obstinately to the skin.

LEAD POISONING IN A FACTORY USING LEAD CARBONATE AND LEAD SULPHATE.

As for the poisonousness of lead-sulphate paint as compared with lead-carbonate paint, an experiment on a large scale was recently made and the results, though not absolutely conclusive, are certainly suggestive. In January, 1912, a railway car company, which had always used white-lead paint (basic carbonate) in the interior painting of coaches and also for the outside of passenger coaches, began to use a paint containing the basic sulphate or oxysulphate in the place of the carbonate. There had always been much lead poisoning among the four hundred and odd painters, especially those who were obliged to paint and sandpaper walls and ceilings inside the cars. Up to that time no attempt had been made to protect the men in any way, no facilities given them for cleanliness, no medical care or instruction, although many of those who did the most dangerous part of the work were newly arrived foreigners. Soon after the change in the paint the company entirely revolutionized the method of treating the workmen. Two completely equipped comfort houses were opened with every facility for washing and bathing, overalls and caps were provided and kept in good order, lunch rooms opened, and overseers put in charge to see that the men made full use of all these things. Physicians were engaged to examine all new men applying for work in this particular department and to examine once a week each employee who handled lead paint. In short, the rules in force in European countries for the protection of workers in white lead were followed here.

The physicians' records covered three periods, the first running from July 1 to December 31, 1911, during which time the company was experimenting with lead-sulphate paint and carrying on investigations to ascertain how much lead poisoning there was among the painters. During the second period, from January 1 to March 1, 1912, lead-sulphate paint was used exclusively, but sanitary provisions for the painters were not yet complete. The third period from March 1, 1912, to April 20, 1913, represents the present state of affairs, viz: Basic lead-sulphate paint, excellent sanitary equipment and supervision, and regular medical inspection. During the first six months an average of 489 men were examined monthly, and 109 cases of plumbism were discovered, giving an average of 18 a month. In the next two months, making the second period, an

average of 649 men were examined and 16 cases of plumbism found, or 8 a month. The third period covers more than 13 months, and during this time the average number of men examined monthly has been 639 and only 3 cases of lead poisoning have been found. Thus the lead poisoning in this workshop fell from an average of 18 cases a month in a force of 489 men to an average of $\frac{3}{13}$ case a month in a force of 639 men.

The physicians who were interviewed maintained that this great improvement was to be attributed to the institution of medical and sanitary care, not to the change in the paint, while the foremen were inclined to give the credit to the paint. The truth is that both were factors. Without the sanitary supervision, some men would probably have been poisoned even with the sulphate paint, but there could never have been so great and so sudden a falling off of lead poisoning if the company had continued to use the carbonate paint, no matter what care was taken. There is no record in the literature of such a rapid improvement following the institution of sanitary measures alone.

However, since the experience of this company could not be taken as absolutely conclusive because both changes had been made at the same time, it seemed best to make an experimental study of these two kinds of paint, and determine the question of their relative poisonousness. The experiments were made in the Hull Physiological Laboratory of Chicago University by A. J. Carlson and A. Woelfel. They worked with the sort of dust which painters inhale when they are sandpapering, and which gets on their hands and faces and hair and clothing. The specimens of dust were furnished by Mr. A. M. Johnson, chief chemist of the Pullman Co. Mr. Johnson had two plates of steel each 2 feet square covered, one with basic carbonate paint and one with basic sulphate paint. The plates were allowed to dry and then the paint rubbed off with sandpaper and the resulting dust collected and tested with human gastric juice and fed to animals. This is Dr. Carlson's report of his findings first with the paint dust, afterwards with basic carbonate and sublimed lead in the dry state.

SOLUBILITY OF BASIC LEAD SULPHATE AND BASIC LEAD CARBONATE IN HUMAN GASTRIC JUICE AND RELATIVE TOXICITY OF THE TWO SALTS AS SHOWN BY FEEDING EXPERIMENTS WITH DOGS AND CATS.

(By A. J. Carlson and A. Woelfel, Hull Physiological Laboratory, University of Chicago.)

There is no evidence that the lead salts are absorbed from the digestive tract or act locally on the mucosa, except when in solution. The strongest solvent in the digestive tract for lead salts is the hydrochloric acid of the gastric juice, and of less importance the lactic acid, and other organic acids produced in the course of hydrolysis of proteins and of fats and of bacterial activity. When one considers

the humane and economic importance of lead poisoning in the industries, the literature on the action of the gastric juice on the different lead salts appears fragmentary. It was even assumed until less than 10 years ago that lead sulphate was practically insoluble in the stomach and intestines. This view led to the practice, still followed by some doctors, of giving sulphuric acid lemonade to lead workers as a prophylactic measure. Blum[1], Goadby[2], Schicksal[3], and Beck[4] have studied the solubility of various lead salts in dilute hydrochloric acid, in various artificial gastric digest mixtures, and in gastric juice. All agree that the lead sulphate is soluble in these media. One of Goadby's two experiments with human gastric juice (10 c. c. gastric juice + 0.1 g. of the lead salts, at 37° C. (98.6° F.) for one hour) appears to show that the lead sulphate is even more soluble than is lead carbonate (white lead) or lead oxide (litharge). The second experiment showed practically the same solubility for the three salts. The work of Blum and Schicksal indicates that the presence of peptone in gastric digest mixture increases slightly the solubility of the lead salts.

RELATIVE SOLUBILITY OF LEAD CARBONATE AND LEAD SULPHATE IN HUMAN GASTRIC JUICE.

Samples of paint dust of "basic lead carbonate" and "basic lead sulphate" respectively, were sent us by Mr. A. M. Johnson, chief chemist of the Pullman Co. Mr. Johnson stated that the samples submitted were typical of the paint dust produced in the Pullman shops by sandpapering painted metal. The dust samples contained, per gram, lead corresponding to the following quantities of lead (determined as sulphate):

	Grams of lead per gram of dust.	
Basic lead carbonate paint dust	1.04 1.04 1.06	average, 1.05 g.
Basic lead sulphate paint dust	.86 .87 .82	average, .85 g.

Samples of sublimed white lead (basic lead sulphate) and of lead carbonate ("Old Dutch Process") not mixed with oil were then tested. On analysis they were found to yield the following quantities of lead (determined as sulphate):

	Grams of lead per gram of sample.	
Lead carbonate	1.12 1.12	average, 1.12 g.
Basic lead sulphate	.98 .96	average, .97 g.

[1] Blum, Wiener medizinische Wochenschrift, 1904, Bd. 54, p. 538; Deutsche medizinische Wochenschrift, 1912, Bd. 38, p. 645.

[2] Goadby, Journal of Hygiene, Cambridge, Eng., University Press, 1909, IX, p. 122.

[3] Leymann, Die Bekämpfung der Bleigefahr in der Industrie, Jena, 1908.

[4] Beck, Arbeiten aus dem Kais. Gesundheits Amt. Berlin, 1910. Bd. 34, p. 446.

Normal human gastric juice was obtained from a man 27 years old, with complete constriction of the œsophagus and a gastric fistula of 16 years' standing.[1]

The juice was secreted while the man was chewing palatable food when hungry. Hence it was normal "appetite" or "psychic" juice, not mixed with saliva. The total acidity varied from 0.40 per cent to 0.52 per cent.

The results are given in Tables I and II. The lead carbonate proved in every case to be much more soluble than the lead sulphate and the lead carbonate paint dust is nearly as soluble as the pure white lead, while the lead sulphate paint dust is less soluble than the pure basic lead sulphate. We are at loss to account for Goadby's results showing greater solubility of the lead sulphate in gastric juice, except on the ground of faulty methods. A greater solubility of lead sulphate than of lead carbonate in gastric juice seems a chemical impossibility. We note that Goadby records only two tests and the lead was determined after centrifuging the digestive mixture instead of in clear filtrate. It seems probable that varying quantities of the lead salts were present in suspension in addition to that in actual solution.

Peptone in concentration of 0.2 per cent and 1 per cent does not have a marked influence on the solubility of the lead salts, but so far as the influence of the peptone is in evidence it may be explained as follows: The formation of lead peptone compounds might lead to the setting free of the chlorine ions in the lead chloride, and thus to the formation of more lead chloride from the carbonate and the sulphate. Our figures show that this is not an important factor in lead poisoning from the digestive tract. (See Summary, p. 31.)

The solubility of the lead salts in pure gastric juice is practically the same as that in similar quantities of 0.5 per cent hydrochloric acid. It is therefore clear that the hydrochloric acid of the gastric juice is the all-important solvent. Pepsin, rennin, and other organic constituents may combine with the lead salts when in solution, but if this is the case the reaction does not appreciably affect the quantity of lead salts held in solution.

TABLE I.—RELATIVE SOLUBILITY OF BASIC LEAD SULPHATE PAINT DUST AND BASIC LEAD CARBONATE PAINT DUST IN HUMAN GASTRIC JUICE.

25 c. c. gastric juice+25 c. c. water+0.5 g. basic lead sulphate paint dust, at 38° C. (100.4° F.) for 10 hours.		25 c. c. gastric juice+25 c. c. water+0.5 g. basic lead carbonate paint dust, at 38° C. (100.4° F.) for 10 hours.	
Experiment number.	Lead dissolved.	Experiment number.	Lead dissolved.
	Grams.		*Grams.*
1	(a) 0.0396	1	(a) 0.1964
	(b) .0276		(b) .2684
2	(a) .0582	2	(a) .2364
	(b) .0680		(b) .2284
3	(a) .0436	3	(a) .2264
	(b) .0400		(b) .2262
4	(a) .0420		
	(b) .0594		
Average	.0473=9.5 per cent.	Average	.2304=46.1 per cent.

[1] A. J. Carlson, American Journal of Physiology, Boston, 1912. XXXI, p. 151.

TABLE II.—RELATIVE SOLUBILITY OF LEAD CARBONATE (OLD DUTCH PROCESS) AND BASIC LEAD SULPHATE (SUBLIMED WHITE LEAD) IN HUMAN GASTRIC JUICE.

Lead sulphate.			Lead carbonate.		
Experiment number.	Digestive mixture.	Lead dissolved.	Experiment number.	Digestive mixture.	Lead dissolved.
		Grams.			*Grams.*
1	25 c. c. gastric juice; 25 c. c. water; 0.5 g. lead sulphate, at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.1260 (*b*) .1210	1	25 c. c. gastric juice; 25 c. c. water; 0.5 g. lead carbonate, at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.2940 (*b*) .3044
2	25 c. c. gastric juice; 25 c. c. water; 0.5 g. lead sulphate; 0.1 g. peptone (*a*), 0.5 g. peptone (*b*), at 38° C. (100.4° F.) for 10 hours.	(*a*) .1376 (*b*) .1284	2	25 c. c. gastric juice; 25 c. c. water; 0.5 g. lead carbonate; 0.1 g. peptone (*a*), 0.5 g. peptone (*b*), at 38° C. (100.4° F.) for 10 hours.	(*a*) .3302 (*b*) .3100
3	50 c. c. gastric juice; 0.5 g. lead sulphate, at 38° C. (100.4° F.) for 10 hours.	.1500	3	50 c. c. gastric juice; 0.5 g. lead carbonate, at 38° C. (100.4° F.) for 10 hours.	.3896

		Grams.	*Per cent.*			*Grams.*	*Per cent.*
Average	(1)	0.1235	= 24.7	Average	(1)	0.2992	= 59.8
	(2)	.1330	= 26.6		(2)	.3201	= 64.0
	(3)	.1500	= 30.0		(3)	.3896	= 77.9

It can be seen, therefore, that the lead carbonate is a little more than twice as soluble as the sulphate.

RELATIVE TOXICITY OF LEAD SULPHATE AND LEAD CARBONATE WHEN FED TO DOGS AND CATS.

Since it is not possible in experiments in vitro, even when normal gastric juice is available, to reproduce some of the essential conditions of gastric digestion, the final solution of the question of the relative toxicity of the different lead salts must be sought by feeding experiments. Goadby fed various lead salts to cats. Five cats received from 0.5 to 0.8 grams dry white lead (lead carbonate) per day for periods varying from 1 to 18 months. According to Goadby, this quantity of lead carbonate per day produced practically no symptoms unless alcohol was given at the same time. One must infer from Goadby's work that cats are unusually resistant to lead salts given by mouth. In an earlier work Lehmann [1] showed, however, that even the slightly soluble lead sulphate produces toxic symptoms in eight or nine days when fed to cats in quantities of 0.2 gram per day. Blum [2] concludes that the sulphate is less toxic than the other lead salts employed in the industries.

FEEDING EXPERIMENTS—SERIES I.—Dogs of nearly the same size and age were selected, and 4 grams of the lead sulphate and the lead carbonate paint dust respectively were fed to the dogs in ground meat, either in one feeding or in two feedings, eight hours apart. The results are summarized in Table III.

[1] Lehmann, Archiv für Hygiene, München und Leipzig, 1892, Bd. 16, p. 316.

[2] Blum, Deutsche medizinische Wochenschrift, Leipzig und Berlin, 1912, Bd. 38, p. 645.

The feces of dogs A and B (Table III) were collected for six days after giving the lead paint dust per mouth, and the quantity of lead determined with the following result:

Dog B, fed 4 grams basic lead carbonate, containing 4.16 grams lead determined as sulphate. Lead recovered in the feces 2.61 grams, or 63 per cent.

Dog A, fed 4 grams basic lead sulphate, containing 3.28 grams lead determined as sulphate. Lead recovered in feces, 3.10 grams, or 95 per cent.

The lead in the feces of dogs C and D was not determined.

TABLE III.—EFFECTS OF 4 GRAMS OF LEAD SULPHATE AND OF LEAD CARBONATE PAINT DUSTS WHEN FED TO DOGS IN ONE AND TWO FEEDINGS.

Day.	Dog A: Weight, 10 K. (22 lbs.).	Dog B: Weight, 11 K. (24.3 lbs.).
First	2.0 g. basic lead sulphate paint dust in meat at 8 a. m. and 4 p. m.	2.0 g. basic lead carbonate paint dust in meat at 8 a. m. and 4 p. m.
Second	Dog normal	Vomiting; great thirst; polyuria; depression; some tremors; no appetite.
Third	Dog normal	Condition same as on second day.
Fourth	Dog normal	Eats a little; drinks and vomits frequently.
Fifth	Dog normal	Condition about same as on fourth day.
Sixth	Dog normal	Considerably improved; eats; does not vomit; but seems depressed.
Seventh	Dog normal	Dog seems fairly normal.
	Dog C: Weight, 7 K. (15.4 lbs.).	Dog D: Weight, 6.5 K. (14.3 lbs.).
	4.0 g. basic lead sulphate paint dust in meat at one feeding. Dog developed some constipation, but no other symptoms of lead poisoning.	4.0 g. basic lead carbonate paint dust in meat at one feeding. Dog ran practically the same course of acute lead poisoning as dog B, with final complete recovery.

FEEDING EXPERIMENTS—SERIES II.—Eight hearty dogs were selected for this test, and grouped in pairs of approximately the same body weight. One of the dogs of each pair was fed the sulphate paint dust in meat, the other one given the carbonate paint dust in meat. The quantity of the lead paint dusts given each dog was fixed to equal 0.1 gram lead sulphate per kilo (2.2046 pounds) body weight. The dogs fed the sulphate paint dust thus received a greater quantity of the dust, as this dust contained a lower percentage of lead than the carbonate paint dust.

The results are summarized in Table IV. The table shows that the dogs receiving the lead carbonate paint dust developed severe symptoms of acute lead poisoning within 24 to 48 hours after the first feeding, while the dogs fed the sulphate paint dust showed very mild symptoms of lead intoxication only after three or four feedings—that is, after 72 to 96 hours. Feeding experiments as tests of relative toxicity break down, of course, as soon as vomiting or lack of appetite appears, as one can not control the quantity of lead salts eaten or retained. For that reason the experiment was discontinued as soon as there appeared symptoms of intoxication in the dogs receiving the least toxic lead salt—that is, the sulphate.

TABLE IV.—EFFECTS OF DAILY FEEDINGS OF LEAD SULPHATE AND LEAD CARBONATE PAINT DUSTS TO DOGS IN QUANTITIES OF 0.1 GRAM PER KILO (2.2046 POUNDS) BODY WEIGHT.

Day.	Basic lead sulphate paint dust.				Basic lead carbonate paint dust.			
	Dog A: Weight, 6.8 K. (15 lbs.).	Dog C: Weight, 12.5 K. (27.6 lbs.).	Dog E: Weight, 10.2 K. (22.5 lbs.).	Dog G: Weight, 12.3 K. (27.1 lbs.).	Dog B: Weight, 7.0 K. (15.4 lbs.).	Dog D: Weight, 13.4 K. (29.5 lbs.).	Dog F: Weight, 10.3 K. (22.7 lbs.).	Dog H: Weight, 14.2 K. (31.3 lbs.).
First...	Normal...	Normal...	Normal...	Normal...	Normal...	Normal...	Normal...	Normal.
Second.	Normal...	Normal...	Normal...	Normal...	Severe diarrhea; vomiting; eats a little.	Diarrhea; feces bloody; great thirst; vomits; eats a little.	Slight diarrhea; otherwise normal; eats well.	Seems normal.
Third..	Normal...	Normal...	Seems normal, but does not eat as much as usual.	Normal...	Diarrhea; depression; vomiting; eats a little.	Diarrhea; vomiting; does not eat.	Diarrhea; vomiting; eats a little.	Depression; some tremors; vomiting; eats a little.
Fourth	Some depression; eats less than normally.	Normal...	Some depression; eats less than normally.	Had vomited during night; eats eagerly.	Diarrhea; does not eat; great thirst.	Condition fair; does not eat.	Diarrhea; vomiting; eats a little.	Diarrhea; vomiting; does not eat.
Fifth...	Refuses food; otherwise in good condition; weight, 6.9 K. (15.2 lbs.).	Slight depression; vomiting; weight, 11.9 K. (26.2 lbs.).	Slight depression: weight, 9.8 K. (21.6 lbs.).	Slight depression; eats less than normally; weight, 12.4 K. (27.3 lbs.).	Condition fair; eats a little; weight, 6.6 K. (14.6 lbs.).	Condition fair; eats a little; weight, 12.8 K. (28.2 lbs.).	Diarrhea; vomiting; does not eat; weight, 9.9 K. (21.8 lbs.).	Diarrhea; depression; eats a little; weight, 13.1 K. (28.9 lbs.)

FEEDING EXPERIMENT—SERIES III.—The results of the feeding tests with the sulphate and the carbonate of lead to dogs do not agree with those of Goadby on cats. It does not seem likely that cats have so much greater tolerance than dogs to lead salts per os. Legge and Goadby claim, indeed, that cats are especially susceptible to lead poisoning. Moreover, Leymann obtained symptoms in cats from feeding 0.2 gram lead sulphate per day for 8 to 9 days. How are Leymann's results on cats and our result on dogs to be reconciled with Goadby failing to produce lead poisoning in cats on feeding the more toxic lead carbonate in daily doses up to 0.8 gram for 2 to 18 months? It is difficult to understand where any material source of error might be concealed in the relatively simple process of mixing lead salts with the food, and observing the animals.

Our own test series consisted of four healthy cats, which we may designate as A, B, C, and D. The quantity of the lead salts mixed with the food each day was fixed to equal 0.1 gram lead sulphate per kilo (2.2046 pounds) body weight of cat. The amount of ground meat, fish, or milk and bread with which the lead salts were mixed was less than each cat would ordinarily eat per day, so as to insure all of the lead salts reaching the stomach.

CAT A.—Fed 0.3 gram lead carbonate per day. The first three days the cat did not touch the food, although a new lot was prepared each morning. On the fourth day the cat ate about four-fifths of the food. No symptoms were observed, but the cat did not touch the food for two days following. On the seventh to the eleventh day the cat ate about one-fourth of the food each day. No obvious symptoms of lead poisoning.

CAT B.—Fed 0.37 gram lead sulphate per day. Cat refused the food-lead mixture the first three days. The fourth day the cat ate all the food, on the sixth to the eighth day about one-third of the food. On the ninth day all the food was consumed, but on the two following days less than half of it was taken. No lead intoxication in evidence.

CAT C.—Fed 0.31 gram basic lead carbonate paint dust per day. First day cat ate about three-fourths of the food-lead mixture; second day cat ate about one-half the mixture. On the morning of the third day the cat had vomited a considerable mass of partly digested meat. The cat seemed depressed during the third to the eighth days and refused all food. During the ninth to the eleventh days the cat ate about one-fourth of the food each day. There were no further symptoms.

CAT D.—Fed 0.3 gram basic lead sulphate paint dust per day. The cat did not touch the food-lead mixture during the first three days. On the remaining 8 days of the feeding period the cat ate all the food on 4 days, and on the other days about one-third of the food. No symptoms of lead poisoning appeared at any time.

This 11-day feeding period convinced us of one thing only, that mixing the lead salts with the food is not a feasible method in the case of cats. The addition of small quantities of lead salts to the ground meat, fish, or milk and bread renders the food mass so unpalatable through taste or odor that the cats will starve for days rather than eat, and one can not be certain of the cat eating even a small portion of the food on any day. In the test of the relative toxicity of the two salts it is, of course, essential that all of the salts given shall reach the stomach each day. The method of mixing the lead salts with the food was therefore abandoned. A second series of four cats was selected and 0.1 gram of the lead salts per kilo (2.2046 pounds) body weight administered in gelatin capsules each morning before giving the customary food. The results are given in Table V.

The cats varied in weight from 2.5 to 3.5 kilos (5.5 to 7.7 pounds). Hence 0.25 gram constituted the smallest and 0.35 gram the largest dose of lead salts given per day. Toxic symptoms were produced by all the salts, but the lead carbonate and the lead carbonate paint dust were distinctly more toxic than the basic lead sulphate and the

lead sulphate paint dust. The toxic symptoms noted were vomiting, loss of appetite, constipation, and depression. The feeding period was too short for the development of the chronic nervous symptoms.

It will thus be seen that cats and dogs show about the same susceptibility to the lead intoxication per os. Lead carbonate and lead sulphate when given daily in quantities up to 0.1 gram per kilo (2.2046 pounds) body weight produce toxic symptoms within 2 to 8 days.

TABLE V.—EFFECTS OF FEEDING TO CATS 0.1 GRAM OF THE RESPECTIVE LEAD SALTS PER KILO (2.2046 POUNDS) BODY WEIGHT EVERY MORNING BEFORE BEING GIVEN THEIR USUAL FOOD.

Feeding day.	Cat I: Fed lead carbonate.	Cat II: Fed lead sulphate.	Cat III: Fed lead carbonate paint dust.	Cat IV: Fed lead sulphate paint dust.
First	Normal	Normal	Normal	Normal.
Second	Vomited	Normal	Normal	Normal.
Third	Did not eat	Normal	Vomited	Normal.
Fourth	Did not eat	Vomited	Normal	Normal.
Fifth	Eats a little; depressed.	Seems normal	Vomited	Normal.
Sixth	Eats a little; depressed.	Seems normal	Did not eat	Normal.
Seventh	Vomited	Seems normal	Did not eat	Normal.
Eighth	Did not eat	Seems normal	Eats a little	Eats a little.
Ninth	Did not eat	Vomited	Eats a little	Did not eat.
Tenth	Did not eat; greatly depressed.[1]	Eats a little; depressed.	Eats a little; greatly depressed.	Eats a little.

[1] This cat developed ataxia, paralysis, and opisthotonos on the twelfth day.

RETARDING EFFECT OF MILK ON THE SOLUBILITY OF LEAD SALTS IN HUMAN GASTRIC JUICE.

We were especially interested in the action of milk on the solubility of the lead salts in human gastric juice and weak solutions of hydrochloric acid in view of the fact that in some places lead workers are required to drink milk before starting to work. And practical experience seems to show that milk or other food in the stomach minimizes the danger of lead poisoning from the digestive tract. When milk and gastric juice are mixed in the proportion of 1 to 1, lead salts added, and the mixture incubated at body temperature for 10 hours, not enough lead goes into solution even to get a qualitative lead test. Only when the lead carbonate paint dust was used, in two cases a positive qualitative test was obtained. The same results are obtained in mixtures of milk and 0.05 per cent hydrochloric acid. But when the ratio of the gastric juice or the hydrochloric acid to the milk is increased, the lead salts are dissolved in proportion to the increase in the quantity of the gastric juice or hydrochloric acid.

TABLE VI.—INFLUENCE OF MILK ON THE SOLUBILITY OF LEAD SALTS IN HUMAN GASTRIC JUICE AND IN 0.5 PER CENT HYDROCHLORIC ACID.

Lead sulphate.			Lead carbonate.		
Experiment number.	Digestive mixture.	Lead dissolved.	Experiment number.	Digestive mixture.	Lead dissolved.
1	25 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) None. (*b*) None.	1	25 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) Trace. (*b*) Trace.
2	25 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) None. (*b*) None.	2	25 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) None. (*b*) None.
3	25 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) None. (*b*) None.	3	25 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) Trace. (*b*) Trace.
4	25 c. c. 0.5 per cent HCl; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.0578 g. (*b*) .0562 g.	4	25 c. c. 0.5 per cent HCl; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.3284 g. (*b*) .3344 g.
5	25 c. c. 0.5 per cent HCl; 25 c. c. milk; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) None. (*b*) None.	5	25 c. c. 0.5 per cent HCl; 25 c. c. milk; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) None. (*b*) None.
6	50 c. c. 0.5 per cent HCl; 25 c. c. milk; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.0126 g. (*b*) .0132 g.	6	50 c. c. 0.5 per cent HCl; 25 c. c. milk; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.1320 g. (*b*) .1218 g.
7	100 c. c. 0.5 per cent HCl; 25 c. c. milk; 0.5 g. lead sulphate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.0590 g. (*b*) .0580 g.	7	100 c. c. 0.5 per cent HCl; 25 c. c. milk; 0.5 g. lead carbonate paint dust at 38° C. (100.4° F.) for 10 hours.	(*a*) 0.4010 g. (*b*) .4340 g.
8	100 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead sulphate at 38° C. (100.4° F.) for 10 hours.	0.1740 g.	8	100 c. c. gastric juice; 25 c. c. milk; 0.5 g. lead carbonate at 38° C. (100.4° F.) for 10 hours.	0.4900 g.

The above action of milk is probably due to the fixation of the hydrochloric acid by the milk protein and the neutralization of the hydrochloric acid by the carbonate of milk. Hence when an excess of milk is added to the gastric juice there will be no hydrochloric acid to effect solution of the lead salts, while in the presence of an excess of gastric juice some free hydrochloric acid remains to act on the lead. We are inclined to the view that the formation of insoluble lead albuminates is a factor of minor importance in the above action of milk.

These experiments in vitro do not reproduce some of the conditions that obtain in normal gastric digestion. The fixation of the hydrochloric acid by the proteins takes place in the stomach as well as in the test tube, so that the presence of proteins retards the appearance of free hydrochloric acid in the contents of the stomach. But the work of Cannon and others renders it highly probable that relaxation of the pyloric sphincter and entrance of the gastric content into the duodenum is ordinarily preceded by the development of some free hydrochloric acid in the pyloric portion of the stomach.

This hydrochloric acid will, of course, tend to dissolve any lead salts in the chyme until it is neutralized in the duodenum. Albuminous foodstuffs can therefore diminish the solution of lead salts in the stomach only to the extent that they fix the hydrochloric acid in the gastric juice.

The taking of milk is a more efficient prophylatic measure than the taking of an equal amount of other forms of proteins, because there is less appetite secretion of gastric juice with milk, and the fat in the milk depresses and retards the action of the gastric secretagogues.

SUMMARY OF CONCLUSIONS ON SOLUBILITY AND FEEDING EXPERIMENTS.

1. Solubility of white lead in human gastric juice.

WHITE LEAD PAINT DUST.

	Per cent.
Soluble in pure gastric juice (25 c. c. gastric juice, 0.5 g. dust):	
Basic lead carbonate paint dust	46.1
Basic lead sulphate paint dust	9.5
Soluble in gastric juice and peptone (25 c. c. gastric juice, 0.1 g. peptone, 0.5 g. dust):	
Basic lead carbonate paint dust	46.0
Basic lead sulphate paint dust	7.3
Soluble in gastric juice and milk (gastric juice 1, milk 1):	
Basic lead carbonate paint dust	None.
Basic lead sulphate paint dust	None.
Soluble in 0.5 per cent HCl (25 c. c. HCl, 0.5 g. dust):	
Basic lead carbonate paint dust	66.3
Basic lead sulphate paint dust	11.4
Soluble in 0.5 per cent HCl and milk (HCl 1, milk 1):	
Basic lead carbonate paint dust	None.
Basic lead sulphate paint dust	None.
Soluble in 0.5 per cent HCl and milk (HCl 2, milk 1):	
Basic lead carbonate paint dust	25.4
Basic lead sulphate paint dust	2.6
Soluble in 0.5 per cent HCl and milk (HCl 4, milk 1):	
Basic lead carbonate paint dust	83.5
Basic lead sulphate paint dust	11.7

WHITE LEAD.

Soluble in pure gastric juice (25 c. c. gastric juice, 0.5 g. lead):	
Lead carbonate (old Dutch process)	59.8
Basic lead sulphate	24.7
Soluble in gastric juice and peptone (25 c. c. gastric juice, 0.5 g. lead):	
Lead carbonate (old Dutch process)	64.0
Basic lead sulphate	26.6
Soluble in pure gastric juice (50 c. c. gastric juice, 0.5 g. lead):	
Lead carbonate (old Dutch process)	77.9
Basic lead sulphate	30.0
Soluble in gastric juice and milk (gastric juice 4, milk 1):	
Lead carbonate	98.0
Lead sulphate	34.8

2. Toxicity of lead when fed to dogs and cats.

The lead carbonate is much more toxic than the lead sulphate, but both salts produce acute lead poisoning when given in quantities of 0.1 g. per kilo body weight per day.

3. The influence of milk.

When milk and gastric juice are mixed in the proportion of 1 to 1, the hydrochloric acid of the gastric juice is so completely fixed by the milk proteins or neutralized by the carbonates in the milk that the mixture has virtually no solvent action on the lead salts. But when the gastric juice is present in excess of the milk, the lead salts go into solution in proportion to the excess of gastric juice. When milk is taken into the stomach there occurs, of course, a similar fixation of the hydrochloric acid, and in addition the total quantity of gastric juice is diminished owing to the inhibitory action of the fat of the milk on the processes of secretion.

4. Three practical suggestions.

On the basis of our work, we venture to offer these three practical suggestions:

(*a*) The lead carbonate is so much more toxic than the lead sulphate that lead workers as well as the State should aim at the elimination of the use of the carbonate in all industries where this is possible.

(*b*) Basic lead sulphate, or sublimed lead, is poisonous and none of the precautions usually advocated for the protection of workers in lead should be neglected by those handling lead sulphate.

(*c*) In addition to taking other important prophylactic measures workers in lead salts should drink a glass of milk between meals (say at 10 a. m. and at 4 p. m.) in order to diminish the chances that the lead they have swallowed be dissolved by the free hydrochloric acid of the gastric juice, as in some persons there is considerable secretion of gastric juice in the empty stomach.

METHODS OF USING AND REMOVING PAINT.

The dangers involved in the use of paint depend upon the constituents of the paint and on the way it is used. No paint need be dangerous if it is used with sufficient caution. If the thinner contains harmful volatile substances, these can be got rid of by proper ventilation of the room in which the work is being done. Men suffer from turpentine, petroleum, benzine, wood alcohol, or amyl acetate poisoning because they are required to use these fluids in closed rooms. The defenders of flat-finish paints, which are leadless but contain dangerous volatile substances, insist that proper ventilation does

away with all possibility of injury to the painter, and this is undeniably true, for proper ventilation dilutes the poison to a harmless point, but they do not take into consideration the fact that the use of certain varnishes and flat-finish paints precludes ample ventilation. Drying must take place in a closed room because drafts of air would stir up dust, injure the surface, or make the coat streaky.

The avoidance of danger from the use of lead paints is not as simple as is the avoidance of danger from volatile thinners, yet here, too, the method of use is of great importance. The dangers which the painter who uses lead paints must face are given by foreign authorities as follows:

1. Mixing dry lead salts with oil or paint.
2. Sandpapering lead-painted surfaces.
3. Rubbing or chipping off old paint.
4. Burning off old paint.
5. Inhaling dust from dirty working clothes and from dirty drop cloths.
6. Carrying lead paint into the mouth from unwashed hands while eating or while handling tobacco.

Now, the first of these is fairly negligible as a source of lead poisoning in this country. White lead is almost never handled dry by the painter and red lead rarely. Out of 100 lead-poisoned painters whose histories were obtained, only 2 mentioned having used dry white or red lead. The danger is one to which paint foremen may be exposed and to a certain extent painters of iron and steel if they use red lead, but the number is relatively very small.

DRY SANDPAPERING OF LEAD-PAINTED SURFACES.

The second is a far more important source of lead poisoning. Sommerfeld thinks that to do away with dry sandpapering would be to remove the worst element in this industry, and the Austrian governmental commission came to the same conclusion. Sandpapering is used to smooth away the roughness of one coat of paint before the next is applied. The more carelessly the first is applied the greater necessity for sandpapering; but a certain amount of it is necessary in all fine-grade work, especially interior work in ship and house painting, where many coats must be applied. A well painted interior usually has from two to four coats of white-lead paint, all but the last of which is sandpapered. Sometimes this last coat is a leadless enamel, but the ground coats are almost always white lead.

In working on carriage wheels or bodies or on the interior of railway cars, a painter may spend from one-sixth to one-fourth of his working time sandpapering, and even while he is engaged in painting

he may have to breathe the dust raised by his fellow workmen. His face is close to his work, and he can not possibly avoid breathing in the dust unless he wears some kind of a respirator.

IMPORTANCE OF DUST AS A CAUSE OF LEAD POISONING.

It is very important to know how lead gains entrance to the human body, because obviously it is not possible to understand the dangers of the painter's trade nor to outline measures for his protection against lead poisoning unless we know whether the skin, the intestinal tract, or the respiratory tract is the most important portal of entry for this poison. Painters themselves, employers, and physicians hold varying views on this question. Some think that the skin is the most important and explain painter's palsy (wrist drop) on the ground that the lead in the paint has passed directly through the skin to the muscles or nerves of the wrist. There are also some scientific authorities on lead poisoning who believe that lead may pass through the skin and cause poisoning, especially in hot weather, though they do not hold this to be the most important mode of poisoning. On the other hand, the majority of German authorities regard skin absorption as of little practical importance in industrial plumbism, and the English regulations governing the lead trades ignore it and are directed entirely to measures for the prevention of lead dust in the air and the prevention of poisoning through the mouth.

As for the relative importance of these last two, the respiratory tract and the digestive tract, there is some difference of opinion. The most recent British work [1] on the subject describes experiments tending to show that lead dust enters the bronchial tubes and lungs and even penetrates the capillaries thus reaching the blood stream. Most German authorities, however, hold that if any lead is absorbed through the respiratory tract it must be small in amount, and that while it is true that the breathing of lead dust causes poisoning, this is not because the lead reaches the bronchial tubes, but because it is caught in the mouth and throat, mixed with the saliva, and swallowed. K. B. Lehmann [2] and his assistants recently traced the path followed by inhaled dust and they state that the great bulk finds its way into the stomach, not into the lungs. It first lodges on the nasal and pharyngeal mucous membrane and the dust-laden secretions are then swallowed. Less than one-quarter at the most reaches the lungs. If the dust is insoluble the stomach may be a good place for elimination, but soluble dusts are easily absorbed. Whichever theory is accepted there is no question that poisoning takes place more rapidly

[1] Legge, Thomas M., and Goadby, Kenneth W., Lead Poisoning and Lead Absorption. London, 1912.
[2] Lehmann, Saito & Majima, Archiv für Hygiene, München und Leipzig, 1912. Vol. 75, p. 160.

the dustier the occupation, and therefore those parts of the painter's trade that are accompanied by dust production are the most dangerous.

MOIST RUBBING OF LEAD-PAINTED SURFACES.

Rubbing with pumice stone and water instead of sandpapering is used much more in European countries than here. It is more expensive because it is very much slower, and painters in this country say that it is impracticable for the first coats as it would raise the grain of the wood or, in metal painting, would cause rust. These objections, however, would not apply to the use of oil instead of water. It is entirely possible to do away with the dust of the rubbing process by keeping the sandpaper moistened with one of the cheap mineral or hydrocarbon oils, choosing one, of course, that has a low flash point and that is neither too slow nor too rapid a drier. The sandpaper lasts as well with as without the oil and the result upon the paint is fully as good. It is a method with which many German painters are familiar and if it could be generally introduced in this country a great step forward would have been taken in improving the conditions in house painting and carriage and railway coach painting and ship painting.

REMOVING OLD PAINT.

Old paint is sometimes prepared for repainting by sandpapering when the surface is wood, and when the repair is only superficial. Painted metal surfaces are generally chipped clean, sometimes by means of a compressed air machine. This work is dangerous in the same way as is sandpapering and the danger varies according to the thickness of the paint that must be removed and the smallness of the inclosure in which the work is done. The most conspicuous example of dusty paint removing can be seen in shipyards, when in repairing steel ships the painters may have to enter the closed spaces between the outer shell of the ship and the inner shell and chip off old red lead paint. Even when artificial ventilation is used, the work is very dangerous.

Burning off old paint is safer than chipping, but it can not be used on thin metal surfaces lest they warp. English and German authorities speak sometimes of the danger of poisoning from the fumes produced by burning off old lead paint, and include this process among the causes of lead poisoning in the painter's trade, but it seems improbable that lead fumes are produced in burning off old paint. The painter uses a small gasoline flame which is hot enough to make the paint shrivel and curl up, but not hot enough to scorch it. The question as to whether this degree of heat would be sufficient to volatilize the lead was submitted to Prof. Julius Stieglitz of the

department of chemistry, University of Chicago, and he answers as follows:

If the painter does not allow a flame to remain more than a moment in contact with the lead paint, I should consider the chance for the evaporation of lead to be extremely remote. The boiling point of lead is at bright red heat, and of lead chloride, which is its most volatile common salt, it is near that temperature (900° C. [1652° F.]). I believe, therefore, that the danger is minimal under those conditions. If, however, he allows the flame to play long enough on the surface to produce a decided smoke, the smoke could then carry mechanically lead particles with it.

It seems more probable that disagreeably smelling fumes from the heated oil cause a feeling of malaise and headache in the painter and that the chief risk of lead poisoning comes from the drying and powdering of the burned off paint after it has fallen to the floor. The Austrian regulations require that all such scraps be gathered up before they have had time to dry.

DANGER FROM DUSTY CLOTHING, ETC.

When sandpapering is done the paint dust falls on the floor, or on the drop cloth. The floor of a factory is oily and the dust becomes incorporated into a paste, but when the floor is covered with a drop cloth, as in house painting, there is risk of contaminating the air with minute quantities of lead dust stirred up by the men as they pass to and fro. Especially is this true at the beginning of work when a dirty drop cloth is first spread out on the floor and the accumulation of former sandpapering shaken into the air. Dusty overalls are objectionable for the same reason.

DANGER FROM PAINT ON UNWASHED HANDS AND FACE.

Sandpapering paint and burning off old paint are not dangers to which every painter is exposed, but every painter runs the risk of carrying lead into his mouth if he handles his food or his tobacco with unwashed hands. The risk is greatest with greasy food, such as buttered bread and meat, as paint comes off easily on an oily surface. This is a danger against which nobody but the man himself can wholly guard, for even the most complete equipment of wash rooms, towels, and soap are useless if the man himself is careless. On the other hand, the most careful man may find it hard to avoid eating with paint-smeared hands when employed on a new building, where there may be no provision at all for washing. The water is usually not turned on in a new building till the work of painting is completed, and there may be no water at all for the men to use either for drinking purposes or to wash with except what is carried up in buckets—empty paint buckets often—from a hydrant in the street. Of course cold water without soap is practically useless for washing paint from the hands, and

few of the men carry soap and towels with them. Often the painter will clean his hands as well as he can on a rag or a piece of paper and then handle his food gingerly, trying to keep some paper between his fingers and his sandwich, though he may quite forget the lead dust on his mustache. Other men wash off the paint in the benzine or naphtha that is provided for the cleaning of paint brushes, but many painters are afraid to do this because they believe that benzine drives the lead in through the pores of the skin. If the painter is careless enough to hang his street clothes in the room where he is working, he will carry the lead dust home with him, too.

The shortness of the noon hour is another thing that prevents the men taking proper precautions. Thirty or forty minutes is not enough to permit them to go home and, without a wash room or lunch room within easy access, they can not get rid of their dirty overalls and eat their meal with clean hands in a clean place. The only warm and clean place available is likely to be the nearest saloon, and many painters do go to saloons for the accommodations which they can not get anywhere else, though others admit frankly that they go for drink and sociability. The temptation to go there is increased by lack of drinking water in the place where they are working, and the dryness of the throat caused by turpentine and benzine vapor.

It is often claimed that alcoholism is very common among painters and is responsible for lowering their resistance to the lead. Painters themselves say that as a class they are rather heavy drinkers, yet according to the vital statistics of one of the large life-insurance companies,[1] which makes a specialty of industrial insurance, painters are a little below the average in deaths from alcoholism. The records of 2,783 deaths among painters contain only 1.4 per cent attributable to alcoholism, as against 1.9 per cent for plumbers and for masons, and 1.5 per cent, the average for 103,434 occupied males. Oliver says there is no evidence that British painters are more intemperate as a class than other workmen.

If a house painter is questioned as to what measures would best protect him from the dangers of lead poisoning, he usually answers, among other things, "hot water and soap and time enough to use them." Yet in their agreements with the master painters and contractors the house painters have rarely insisted on a long lunch hour. It would be easy enough for them to add on a half hour at the end of the day and lengthen the noon hour. It is probably true that in large cities house painters have to go too great a distance from home to make it possible for them to get there and back again in the middle of the day, and therefore a longer lunch period would not help much. In factories the situation is much simpler. Here it would be easy to

[1] Prudential Insurance Company of America. Exhibit for International Congress on Hygiene and Demography. Washington, 1912, pp. 24 and 31.

insist upon clean lunch rooms and well-equipped wash rooms, but the union does not hold sway in factories. As it is, some workshops are very well equipped, but the majority that have been visited give a far from sufficient provision, and some, especially the smaller ones, give none at all.

On the whole it is probably fair to say that many painters are careless as to personal cleanliness and do not take nearly as many precautions as they should, while others who are alive to the dangers have no chance to take precautions, because there is no provision for cleanliness where they are working.

HOUSE PAINTING.

Outside painting, house and sign painting, does not involve much risk of lead poisoning from dust, only from contamination of food and tobacco through paint-covered hands and mustache. Sandpapering is a negligible risk in outdoor work. The essential thing is to have some provision for the men to get rid of the paint on their hands and faces before they eat their lunch.

Interior work is fraught with much more danger of plumbism than outside work because of the exposure to dust from sandpapering. In interviews with Scandinavian and German painters, of whom there are many working in this country, one is told that the methods used in interior work in European countries are safer than our methods; that less white lead is used on this class of work, zinc oxide, or lithopone taking its place. Many Scandinavian painters said they never had used white-lead paint for inside work till they came to this country. Zinc oxide has not the covering power of white lead, requiring as it does so much more linseed oil, and therefore four coats of zinc paint are needed to do the work of three coats of lead paint. As labor is the great item of expense in house painting in this country, that extra coat makes zinc paint less desirable than lead paint to the American contractor. Then, too, American painters are not so familiar with zinc paint as with lead paint and handle it with less skill. Even when lead paint is used, these men who have had foreign training say that the work is not as bad in Europe as here for the paint is put on more slowly and carefully and does not need so much sandpapering. This again is a question of saving expense by saving time.

Another thing that adds to the unhealthfulness of interior painting is the dampness and cold of new buildings during the spring and fall months, when a great deal of the work on new construction is done. Rheumatic pains are so frequent a trouble among painters that the men regard them as a matter of course, but such pains are among the symptoms of lead poisoning, and a damp and cold atmosphere lowers the resistance of the body to lead.

SIGN PAINTING.

Sign painters are closely affiliated with house painters and in small places they are members of the same "mixed locals" with house painters and carriage painters. There is, however, a separate trade organization in larger cities, comprising between 2,000 and 3,000 members, about one-fourth of whom hold their membership in Chicago.

Sign painting is a highly skilled branch of the trade, requiring a four-year apprenticeship, which is sometimes extended to five years, while the apprentice time for house painters is only three years. The organized sign painters are English-speaking men, chiefly American born or from northern Europe, though Bohemians and various nationalities of Jews are beginning to enter the trade. There has been a gradual change in the industry in the last 10 or 15 years, leading to the substitution of shopwork for outside work. Not only signs for business houses but advertising bulletin boards, what we usually call "sign boards," are now prepared in the shop. The separate boards, which are made of galvanized iron, no longer of wood, are painted inside the shop and then fitted together outside. Lead paint is chiefly used, but sandpapering is a very insignificant feature. Indeed, sign painters do not think of mentioning this as a bad part of the work because there is so little done. There is also much less paint used by sign painters than by house painters, for so much of their time is taken up in painstaking lettering and ornamentation. Practically the only outside work among sign painters now is the painting of advertisements on the sides and roofs of buildings. Here the dark background is generally a leadless paint and only the light-colored letters and designs are put in with lead paint.

Volatile substances are not as great an evil in sign painting as in house painting, partly because there is not nearly so much paint used in proportion to the number of men working, partly because paints with a large proportion of turpentine, benzine, or naphtha are not adapted to this work. There is a good deal of gilding with gold leaf and a smaller amount of silvering with silver and aluminum leaf, but the liquid suspensions are not used and there is very little bronzing.

The hours are the same as those for house painters except that the sign painters belonging to the Chicago local take an hour at noon. When on shopwork the men usually bring their lunches, but on outside work they depend on restaurants or saloons. Sign painters almost always wear gloves while at work. There is no piecework in the industry. It is looked upon as more healthful than house painting, though not as healthful as in former years, when it was almost entirely an outdoor industry.

SHIP PAINTING.

Ship painting is fraught with more dangers to the health of the painter than any other branch of the trade, according to the statements of men who have been both ship painters and house painters. This is partly because the work is of a high grade, requiring many coats of pure lead paint and turpentine, with the usual accompaniment of dry sandpapering. Then, too, much of the work is done in poorly ventilated spaces, down in the hold, for instance, or inside small cabins, or, even worse, in the so-called water bottoms, the spaces between the inner and outer shells of the ship. Fumes of turpentine and of hot coal tar and dust from sandpapered red or white lead accumulate in these airless places and bring about a condition which could hardly be paralleled in house painting.[1] A description of one of the four large shipyards on the Atlantic coast will serve to show the risks attendant on this work. Conditions are fairly similar in all four, though the one selected is considered one of the best.

There are between 125 and 150 painters employed here, about 25 or 30 of them colored, the others white. Most of the whites are members of the Brotherhood of Painters and Decorators, this being an open shop. The force varies very much, the men coming and going all the time. At the time this inspection was made the foreman was advertising in the papers of near-by cities for 50 painters. He said quite frankly that the men could not stand the work as long as they could house painting, especially because of the turpentine fumes. He himself had had both lead and turpentine poisoning.

The outside painting of ships is not particularly trying, done as it is in the open air where fumes and dust are blown away. Yet some risk there must be in sandpapering the dry paint and in removing old paint with a compressed air chipping apparatus, for the paint above the water line is all red lead or white lead. Below the water line the hull is covered first with an anticorrosive coat applied directly on the steel and consisting of zinc oxide, metallic zinc, and Indian red. Over this comes an antifouling paint, which, as it is poisonous, keeps the ship bottom clear of barnacles. The poison is usually red oxide of mercury on a zinc base.

Above the water line comes red lead and linseed oil, mixed fresh every day. Two coats are applied, the first one sandpapered. Then a "rivet cement" which contains white lead is applied over the red

[1] In the United States Naval Medical Bulletin, 1912, Vol. VI, p. 161, Medical Inspector E. R. Stitt, U. S. Navy, reports three cases of lead poisoning which occurred as the result of the inhalation of dust from old red-lead paint. The men had been employed in chipping off this paint in the compartment of a torpedo boat destroyer. All of them suffered profound nervous symptoms which masked the true condition so that lead poisoning was not suspected until a blood examination showed basophilic changes in the red cells. One of the three developed maniac depressive insanity, the second had epileptic form seizures, and the third was apparently in the early stage of dementia praecox of the hebephrenic type, later developing a neuritis of both arms. All three recovered. Strangely enough, there were no other cases of plumbism among the men, no typical case of colic. Stitt believes that encephalopathy is more likely to result from dust inhalation than from other mode of poisoning.

lead and sandpapered and then two or more coats of pure white lead in linseed oil with a little turpentine. Each coat is sandpapered before the next is applied.

Much more unhealthful is the inside work, for here white lead paint is sandpapered and there is in addition much more turpentine than in the outside work. The last coats, often consisting of equal parts of zinc oxide and white lead, are rich in turpentine; indeed the very last coat may contain no oil at all, being thinned with turpentine alone. The painters say that this part of the work is very trying, and in the lower parts of the ship the fumes from turpentine are sometimes so strong as to overcome the men so that they have to be carried out and laid on the deck to revive. Four men in this yard, who were recently asked to hurry through the painting of a cabin which had no ventilation because the fan was not working, developed symptoms of turpentine poisoning before they had finished the day. The fumes were so strong that they could work only 15 minutes without going up to the fresh air. They suffered from pain in the lumbar region, strangury and bloody urine.

Petroleum fumes are given off from the "bituminous composition" used in the water bottoms and tanks. This is a mixture of Trinidad asphalt, rosin, and coal tar melted together and strained and applied when hot. It is considered a good preservative for steel surfaces. Dense white fumes come off from this mixture, which are extremely irritating to the eyes and throat, and many men suffer also from headache, nausea, and symptoms of intoxication. One man in this yard became wildly delirious while at work with it, but recovered in the fresh air. Other men notice the effect more when they reach the open air, and reel and stagger like drunken men. In this shipyard, efforts are made to relieve the situation when the men are applying this bituminous paint in the water bottoms. A fan is placed in each of the two small manholes leading down from the lowest deck to the water bottoms, and air is driven in and sucked out again; but in addition to this it is necessary to introduce a pipe with compressed air and place it so that the blast drives away the fumes from before the painter's face. Even with these attempted ameliorations the work is refused by white painters and only Negroes can be got to do it. The white men insist that they suffer from the fumes which escape from the water bottoms and reach the parts of the ship where they are working. It is said that a certain tolerance to the fumes is established in some men; the Negro engaged in making the mixture has done that sort of work for 10 years, and apparently he suffered no discomfort when standing in thick white clouds which came from the kettle and which were very irritating to the investigator standing 15 feet away.

Another feature of ship painting which makes it worse than house painting is the fact that the piecework system is in force in shipyards. This means that the men work as fast as they can and pay little or no attention to keeping clean. Ship painters say that they need three or four times as many clean pairs of overalls as they do when they are house painting. Most of them wear gloves, which is an advantage. The noon period is 40 minutes in this particular yard, but the washing facilities are insufficient, only three basins for 75 men, and the basins are at a long distance from parts of the yard. The result is that not nearly all of the men wash their hands before eating.

WAGON AND CARRIAGE PAINTING.

This may be one of the safest branches of the painter's trade or it may be one of the most dangerous. As a rule the large factories are safer than the small shops and the cheaper grades of work safer than the more expensive grades. There is an unduly large proportion of lead-poisoned painters in the smaller carriage and wagon shops, where all the work is carried on in the same room, is done by hand, and the dust from sandpapering contaminates the air, exposing to lead dust even those workmen who are not engaged in dusty work. Many of these painters are newly arrived foreigners, who may be quite ignorant of the dangers of the work and of the way to protect themselves, coming as they do from an agricultural life without any experience in work of this sort. The sandpapering of wheels is the most prolific source of lead poisoning in these shops.

A fairly high-priced carriage, or an automobile with a wooden body, is first oiled; then, after thorough drying, receives a coat of white lead paint and then white lead putty to fill all inequalities of the wood. This is sandpapered. A coat of "rough stuff" and white lead and several coats of rough stuff alone follow, these last being rubbed down, but the dust is quite free from lead. Color coats and color varnish coats are smoothed with pumice and felt and finally with pumice and water. Cheaper vehicles have fewer coats of rough stuff, color, and varnish, but the most dangerous part of the work, the sandpapering of lead putty and paint, is done on the cheaper work also. Painting white milk carts with many coats of white lead is one of the worst branches of this industry in Chicago.

Repairing and repainting old carriages and automobiles is not productive of much lead dust. If the old paint is sandpapered it is chiefly varnish dust that comes off; the rubbing does not go deep enough to reach the lead paint. For thorough repairing the paint is burned off. Metal parts are treated with paint removers.

When the work is done on a very large scale the gear, body, and wheels of the wagons and carriages are dipped by machinery in great tanks of paint, and painting by hand may be limited to the decorations on the last coat. In one factory employing 300 painters all

but a few are engaged in dipping. This is the method in use in this place: The gear of the wagon is dipped in a tank of leadless paint, the primer, swung out over a drip board, and when almost dry rubbed off rapidly with sandpaper. Then it is dipped in paint which contains 50 per cent orange mineral or lead oxide, but this coat is not sandpapered. In the same way the wheels and bodies of the wagons are covered with a leadless primer and a coat of lead paint, either the oxide or the chromate. The only danger comes from the saturation of the clothes of the painter, who is smeared from top to toe with paint. The men who dip the wheels in shallow tanks of paint use their feet to make the wheel turn around in the paint, and even their shoes are soaked through. It requires a great deal of effort, repeated every night, to get rid of this paint, and as a matter of fact the men do not get rid of it. A Hungarian physician who saw these painters in his practice said that he could always tell in which department a man was working by looking at the skin of his arms. This physician treats many cases of chronic lead poisoning and a few cases of acute lead poisoning from this factory. The painters who do the dipping are foreigners and many of them have never painted before, for the work requires very little skill. In proportion to the number of men employed there is not much lead poisoning in this factory, showing that when dust is eliminated a good deal of the danger has been removed.[1]

In this same factory the finer work on carriages requires more hand painting and sandpapering and less dipping. Carriage wheels are given three coats of a practically pure white lead paint, and are sandpapered twice, the dust being brushed off with a large soft brush. As for the body of the carriages, these must have from 20 to 25 coats, many of them of lead paint. Only those applied first are rubbed with sandpaper, the later coats are rubbed down with pumice and water. In this factory the different processes are carried on in separate rooms, which is a great advantage.

AUTOMOBILE PAINTING.

There has been a great change in the method of painting automobiles in this country, since steel and aluminum have almost displaced wood in the construction, and fortunately the change has resulted in making the work of the painter less dangerous than formerly.

In a large factory employing 515 painters, where low-priced automobiles are made, the following method is used: The steel bodies and fenders are either dipped or sprayed with a priming coat which contains lead, color coats and color varnishes that are free from lead.

[1] A careful inquiry was made in the city where the factory in question is situated and 23 physicians were interviewed. With the exception of the Hungarian doctor quoted above, none of these physicians had seen much lead poisoning from the factory, and records could be obtained of only 9 recent cases.

Sandpapering, the worst feature of carriage painting, is not required at all. The only rubbing down is done on the final coats with water and pumice. Chassis receive three coats by hand, the first one being lead and oil, the other two being color varnishes. A little dry sandpapering is done on this first coat. Fenders are simply dipped. Wheels are primed with linseed oil and white lead, but not sandpapered nor puttied; they are then dipped by machinery in a coat of lead paint, and then in color varnish. There is no sandpapering at all. Very few skilled painters are required in this factory; most of the men are ordinary day laborers.

In a second factory, where high-priced automobiles are made, the methods differ somewhat. Here the bodies and fenders are of aluminum. Three hundred and sixty painters are employed, a great many of them doing unskilled work. The priming coat for the aluminum contains no lead, and though the putty used is 60 per cent white lead it is not sandpapered; in fact there is practically no sandpapering done on the aluminum. The "rough-stuff" coats, consisting of about 20 per cent white lead, are not rubbed, and the color and color-varnish coats, also containing white lead, are rubbed with pumice and water. Wheels are painted with a priming coat of oil and a little white lead; then an earthen filler is rubbed in with the hand, but this is free from lead. The color coats contain lead, but they are not sandpapered. Of course many natural-wood wheels are also used with varnish only, no paint.

Thus the most dangerous part of coach painting, the dry sandpapering of lead paint and putty, has been practically eliminated from automobile factories and hand work has been largely displaced by dipping and spraying.

Both these factories are new, large, roomy, well ventilated, and scrupulously clean. In one of them, heavy paper to catch the paint is tacked down every day under the machines and is taken up at night, leaving the floor clean. Detroit is the chief center of the automobile industry, and lead poisoning is a rarity there, both in the hospitals and in the practice of outside physicians. The Detroit local of the Brotherhood of Painters and Decorators has some 25 of its members employed in automobile factories, and the secretary stated that lead poisoning is not at all common in this branch of painting.

This class of painting is done in either nonunion or open shops, and the piecework system is general.

RAILWAY-CAR PAINTING.

A new method of painting railway cars has come in with the introduction of steel construction. Lead-sulphate paint has been found by one large company to be well adapted for covering steel and, as

we have seen already, the adoption of this paint in place of the former lead-carbonate paint was followed by great improvement in the health of the men. Wooden passenger coaches, refrigerator cars, and street railway cars are still painted with lead carbonate, the proportion of lead carbonate depending on the color that is used. Light colors are richer in lead carbonate than are the darker colors. Freight and baggage cars are painted with leadless paint.

Much of what has been said about automobile painting is true of this class of work as well. These shops usually employ both union and nonunion men. The work is in part skilled work, requiring experienced painters, in part it is very simple, such as can be done by day laborers. Sandpapering of lead paint must be done on passenger coaches and street cars, and in repair shops there is a great deal of sandpapering and burning off of old lead paint, the dry fragments of which are often allowed to accumulate on the floor of the shop until they are ground to dust. Fortunately the work is usually carried on in large, well-ventilated barns. The worst part is painting and sandpapering interiors, toilet rooms, or ceilings of passenger coaches and the inside of railway mail cars.

AGRICULTURAL IMPLEMENTS, STRUCTURAL IRON, ETC.

The painting of agricultural implements is hardly a lead trade any longer. In the two plants visited, one employing 75 and the other 165 men[1] in the paint departments, very little if any lead paint is used. Seven men out of the 75 in the first factory use it in stenciling and striping. The painting consists in dipping by machinery into tanks of leadless paint.

Structural iron also is painted more and more with leadless paint. When red lead is demanded, it is usually applied in the shop by men who are not painters by trade and who do this work only occasionally. If it must be applied after the iron is in place, it is done by house painters, a small number of whom are willing to undertake this rather hazardous work on buildings and bridges. The statement is made by bridge and tank contractors that three-fourths of the paint used on their work is carbon or graphite or coal-tar paint. When red lead is used, the ready prepared variety is chosen unless specifications call for dry red lead in linseed oil.

FURNITURE, PICTURE FRAMES, MOLDINGS, ETC.

This branch of factory painting is of very little importance, for leadless paints are used almost entirely. One large paint house stated that it had given up that branch of the trade as the demand for lead paint was too little to be worth while troubling about.

[1] This company employs 840 painters in all its plants.

LEAD POISONING AMONG PAINTERS IN EUROPE.

It is harder to control lead poisoning in the painting trade than in any other, and no country has been able to bring the trade under supervision so as to reduce the amount of industrial poisoning as has been done by means of sanitary regulations in such industries as white lead, smelting, paint grinding, or pottery glazing.

In Germany, according to Fleck,[1] other lead trades have shown great improvement in recent years in the incidence of plumbism, but it is rare to find in any place a diminution in the number of lead-poisoned painters. Fleck says that plumbism is really the occupational disease par excellence of painters, and he believes that a complaint of sickness on the part of a painter should at once arouse suspicion of lead poisoning. Among the common causes of death among painters are acute and chronic nephritis, apoplexy, meningitis, suppuration, and septicæmia from wounds. In Berlin in 1903 the general death rate, leaving out children under 1 year, was 11.61 per 1,000 inhabitants, while for painters over 14 years it was 14. "Without exaggeration it may be stated that every member of this industry, if he does not die early from some other disease, is almost sure to be affected some time with saturnism. Indeed, it has been stated that five years is the longest possible period between the beginning of lead absorption and the outbreak of the intoxication."

Fleck gives the morbidity rate from plumbism per 100 painters in Berlin in 1905 as 7.9, the mortality rate per 100 German painters in 1905 as 1.3. Moreover, Sommerfeld,[2] in writing on lead poisoning in painters, says: "In studying the sickness statistics of painters we must remember that the effects of lead are often given as an independent disease; for example, gastric catarrh, nervous troubles, and rheumatism. Of course nobody can say how many of these were influenced by the lead, but experts agree that the number of lead-poisoning cases is higher than figures show."

The statistics of lead poisoning among painters in Great Britain are incomplete because house painting does not come under the factory and workshop act, which requires physicians to report cases of plumbism to the Home Office. Many physicians, however, do voluntarily report their cases, and the number thus sent in, though not complete, is larger than that reported from any other one industry. In 1909, 167 cases were reported among painters, 7 of them fatal. Legge and Goadby estimate 9,418 cases in this industry in a year, but in the absence of information as to the number of painters in Great Britain, it is not possible to say how large a morbidity rate this is. Painters would, of course, be at the head of the list of industrial plumbism in any country because numerically they stand at the head of the lead trades.

[1] Weyl, Handbuch der Arbeiterkrankheiten, Jena, 1908, p. 513.
[2] Handbuch der Gewerbekrankheiten, Berlin, 1898.

The industries in Great Britain which show a diminution of plumbism in the last 10 years are, as in Germany, those which are subject to strict regulation, as, for instance, the making of white lead, where the cases numbered 358 in 1900 and only 32 in 1909. In the painting industry, on the contrary, no improvement is noticeable. Coach painting, ship painting, and painting in other industries were responsible for 152 cases in 1900, 144 cases in 1903, 140 in 1906, and 167 in 1909.

There is also a larger proportion of severe cases and a smaller proportion of mild cases among the painters who suffer from plumbism than among the cases reported from the other lead industries, as the following shows:

PER CENT OF CASES OF PLUMBISM OF EACH SPECIFIED DESCRIPTION IN GREAT BRITAIN.

Industry.	Severe.	Moderate.	Mild.	First attack.	Second attack.	Third attack.
Coach painting	26.0	27.6	43.2	59.8	18.7	16.8
Ship painting	35.6	19.5	41.4	69.0	15.7	9.2
Painting in other industries	31.4	23.9	43.0	58.8	20.5	17.5
Average for other lead industries	28.2	24.7	44.7	67.4	15.5	13.4

The statistics on lead poisoning in the painter's trade in France have been the subject of bitter controversy between those who advocate the prohibition of white lead paint and the master painters. It is difficult to glean impartial statements from the mass of evidence on both sides. In the Senate report of 1900 the answers of 6,750 master painters and painters are given to questions propounded by the Government. Of these, 134 reported that they had had lead poisoning.

An Austrian governmental report of 1907 gives the results of an official inquiry into the use of lead paint in the painting trade. The report is a very thorough description of the different branches of the painter's trade in that country, the measures for protecting the workmen, and the health of the latter as shown by sickness insurance statistics.[1]

A great deal of red lead is used for structural ironwork in Austria and for ship painting, though in the latter industry zinc white is beginning to replace white lead. For railway cars also the tendency is to use lithopone and zinc white but wagons and carriages are still painted with white lead except in one establishment where, contrary to usual custom, even the outside coats consist of zinc white. Agricultural implements are painted with red lead and white lead.

The seasonal variation in the incidence of plumbism among painters has been interestingly worked out in the Austrian publication quoted, and the curve of lead poisoning follows in general the curve of em-

[1] Austria. Arbeitsstatistisches amt. Bleivergiftungen in hüttenmännischen und gewerblichen Betrieben. Ursachen und Bekämpfung 5. Teil. Wien, 1910.

ployment, only as one would expect it lags somewhat behind. The highest points in the curve of employment are reached in August, September and October, while the greatest amount of lead poisoning comes in October, November, and December.

The investigators distinguish between the two kinds of work, inside and outside painting, for they find that by far the greatest amount of lead poisoning is caused in the former work and this they attribute to dry rubbing and the resulting contamination of the air with poisonous dust. The report states that there is great lack of proper sanitary supervision of this industry in Austria and while the difficulties in the way of providing facilities for cleanliness are much greater when the work is done outside of factories, still these difficulties are not insuperable. For outside work it would be quite possible to provide for wash basins, wardrobe, and lunch room in the building put up by the contractor to shelter materials and blue prints. For inside work, a room could always be set apart as wardrobe and wash room, another as lunch room.

As we shall see later, the findings of this report resulted in the passage of a law which among other things forbids dry sandpapering of lead paint and restricts very largely the use of lead paint in interior work.

LEAD POISONING AMONG PAINTERS IN THE UNITED STATES.

It is unnecessary to remind the reader that the statements made under this heading are only tentative and that it is absolutely impossible to make even an approximate estimate of the amount of lead poisoning that exists among painters in this country.

SOURCES OF INFORMATION.

The United States census for 1910 is not yet available, but in any case it would be of little value because it gives no information as to morbidity rates, only mortality, and for many reasons mortality statistics are of little value in a study of lead poisoning. Rarely does a painter die of uncomplicated and typical lead poisoning. The immediate cause of death is usually some chronic lesion which has been set up by the slow absorption of lead, but the physician in making out his death certificate gives the disease which is, strictly speaking, a secondary cause of death as the principal cause, and the underlying chronic plumbism is either omitted or mentioned as a contributory cause.

The Prudential Insurance Co. has published mortality statistics which have the great advantage of dealing with painters as a separate class, but they also are mortality statistics and the number of deaths from lead poisoning is low, 42 out of 2,783. The figures correspond fairly well with those given by Fleck for German painters in 1905,

although the classification of causes of death is not the same in all cases. In Fleck's records the mortality from lead poisoning is 1.3 per cent; from nervous diseases, 7.8 per cent; from heart, kidney and liver troubles, 20.8 per cent; while the Prudential figures under the same headings are 1.5, 10.7, and 35.9 per cent, respectively. The large rate for respiratory diseases among the German painters, 41.6 per cent, as compared with the Prudential, 26.3 per cent, makes up for this difference.

As to morbidity records, they are very scanty. The report of the Illinois Commission on Occupational Diseases for 1911 gives 578 cases of industrial lead poisoning occurring between 1908 and 1910, inclusive. One hundred and fifty-seven of these, or 27 per cent, were painters. The report states that these cases were gained mostly through the records of the union and that it was very difficult to get at those among nonunion men, who make up so much of the force in railway, wagon, and carriage works.

In the course of an investigation of the white and red lead industries, 300 cases of lead poisoning were gathered from hospital records in four cities and classified according to occupation. Ninety-two of them were painters, not quite one-third. These cities, Chicago, Philadelphia, Camden, and Cincinnati, all contain white-lead factories, so that the proportion of painters is probably lower on that account. In New York, painters seem to make up the great majority of victims of industrial plumbism. The Report on Occupational Diseases, by E. E. Pratt, published by the New York Factory Investigating Commission in 1912, gives the records of 109 cases of industrial lead poisoning, no less than 42 of them painters. In Bulletin No. 95, Bureau of Labor, John B. Andrews quotes the record of one New York hospital in which 59 cases had been treated, 28 of whom, or a little less than one-half, were painters. Among the 60 fatal cases of industrial poisoning studied by Dr. Andrews, 40, or two-thirds, had been painters, showing, apparently, that the form of lead poisoning from which painters suffer is above the average in severity, for the proportion of painters among the fatal cases in New York is higher than the proportion among hospital cases. This accords with statistics in other countries and must not be taken to mean that the painters' trade is the most dangerous of the lead trades, but rather that men remain longer in it. Painters are skilled and well-paid workmen and cling to their occupation as long as possible.

An unusual and interesting statistical report has been recently made and published by a local district council of the Brotherhood of Painters, Decorators and Paper Hangers, the first instance of a study of industrial hygiene made by the industry itself. The

pamphlet, which was compiled by J. A. Runnberg, statistician for Painters' District Council No. 14, and published in Chicago in 1911, deals with three subjects: (1) Nationality and conjugal condition; (2) unemployment; (3) industrial accidents and diseases. The information on which this report is based was gathered from 1,388 letters in answer to 7,195 questionnaires. The average age of these 1,388 men reporting was 41 years and 3 months. As the questions related to nationality, unemployment, etc., as well as to diseases, it is not probable that the questions were answered chiefly by men who had been ill and neglected by those who had not. Indeed, Mr. Runnberg's report shows that the answers came largely from four locals, those containing the greatest percentage of Scandinavian and German members. It may be, however, that the number reporting illness is somewhat above what the average would be for the whole local. The particular illness reported is supposed to be given according to the diagnosis of the physician who treated the case.

Number questioned from 4 local unions	5,031
Number reporting	1,609
Number reporting illness:	
Lead poisoning	185
Kidney trouble	72
Stomach trouble	24
Rheumatism	77

This would indicate that one out of every five or six painters (house painters chiefly) has had lead poisoning at one time if he is not suffering at present from chronic poisoning.

It is interesting to compare these figures with the result of a similar inquiry made among Austrian painters by the Austrian commission referred to above. Of 208 painters who were questioned, 50, or almost 1 in 4, gave a history of having been leaded at least once, most of them repeatedly.

No one can say how many of the 77 cases of rheumatism and the 24 cases of "stomach trouble" were to be attributed to the use of lead paint; some of the cases of kidney trouble were probably to be traced to the effect of turpentine, but a certain proportion would probably have to be explained as due to the chronic vascular changes—arterio sclerosis—characteristic of slow lead poisoning.

It is not claimed that these figures are more than suggestive, and since there was no absolutely accurate information to be obtained as to the frequency of lead poisoning in this industry, it was decided to select a typical group of painters and have a thorough medical examination made of each one. In this way a cross section of the industry could be presented and it would be possible to say how large a proportion of working, not disabled, painters belonging to that

particular class showed evidences of industrial plumbism. The Austrian publication already quoted gives a few details of the investigation made among painters. Of the 208 men selected 112 had the lead line, though in 41 it was only a trace; 50 gave a history of lead poisoning, and 23 of these said that their first attack had come on in consequence of the dry sandpapering of lead paint.

Our investigation was carried out by Dr. E. R. Hayhurst, formerly of the Illinois Occupational Disease Commission, now of Rush Medical College, Chicago.

EXAMINATION OF 100 PAINTERS FOR EVIDENCES OF LEAD POISONING BY EMERY R. HAYHURST, M. D., SPRAGUE MEMORIAL INSTITUTE AND RUSH MEDICAL COLLEGE, CHICAGO.

These examinations were made between February 22 and April 4, 1913. The source of material was from the membership of the Scandinavian Local Union 194, Brotherhood of Painters, Decorators, and Paper Hangers of America, whose officials, particularly Mr. John A. Runnberg, statistician and trustee, and Mr. G. M. Hansen, secretary, arranged to have the men come at stated times for examination.

These workmen constitute the highest type of house painters to be found in Chicago as regards intelligence, industry and thrift, morality, personal hygiene, and interest in personal and community health. A large per cent were of foreign extraction and training, but according to their own statements had used very little lead paint until coming to America.

Age.

Age group.	Number.
20 to 30 years	21
31 to 40 years	26
41 to 50 years	33
51 to 60 years	17
Over 60 years	3

Branch of trade.

General painters, many doing some paper hanging	63
Interior painters and decorators, some paper hanging	32
Exterior painters, exclusively	2
Carriage painters, exclusively	1
Paper hangers, doing some painting	2

Nationality.

Scandinavian	51
German	9
Hebrew	9
Other foreign born	11
American	20

Time at trade.

Two men had begun the trade at the ages of 30 and 31, but with these exceptions all had begun as youths.

Years at the trade.	Number.
Under 5 years	1
6 to 10 years	17
11 to 20 years	32
21 to 30 years	28
31 to 40 years	17
41 to 50 years	4
54 years	1

Where trade was learned.

United States	48
Abroad	41
Not ascertained	11

Time lost during winter of 1912–13 because of lack of work.

Time lost.	
Under 1 month	12
Not over 2 months	16
Not over 3 months	10
Not over 4 months	19
Not over 5 months	2
Over 5 months	3
No time lost	21
Not ascertained	17

It should be stated that these examinations were made at the end of the winter slack season, consequently all the men examined should have been as free from immediate effects of lead poisoning as possible.

Marital history.

	Number.
Single (always)	24
Married	76
Married, but wives never pregnant	11

Father's occupation that of painting in 15 cases.

Significant family history.

Tuberculosis: Eight positive, 4 questionable.

Insanity and epilepsy: Five positive, 2 questionable, out of 70 inquiries.

Cancer: Nine positive out of 75 inquiries.

Significant personal history.

No previous diseases other than venereal and poisoning from lead, 53.

Operations for appendicitis, 2.

Wood alcohol poisoning, 3; recovery complete in 1 case; partial in 2.

Forty-seven gave a history of acute infectious diseases, 11 of malaria, 3 of tuberculosis, 1 of nephritis, and 1 of jaundice.

The inquiry as to the use of intoxicants was answered with apparent frankness; 34 said they drank only occasionally; 42 regularly, but moderately; 14 drank to excess; and 10 were total abstainers. As would be expected from the nationality of the majority, beer was the usual beverage. Twenty-two never drank any whisky, and the 14 excessive drinkers preferred beer. There was no reason to suspect that any of them were given to the use of habit-forming drugs.

In taking their histories the examiner encouraged the men to say what they considered to be the most unhealthful features of their work. Practically all complained of being made sick temporarily by the fumes from "hard oiling" (varnish with benzine and turpentine). Of the 100, 99 complained of the lead-paint dust from sandpapering, the one exception being a man who worked at paper hanging chiefly; 70 of them complained of benzine when used in close quarters; 64 of turpentine. None of them used wood alcohol to any particular extent, except the 3 victims of wood alcohol blindness who had been working in brewery vats.

The examination included a careful inquiry into past history of sickness and present symptoms of ill health, followed by a physical examination, to which was added a skin test for the detection of remnants of lead paint, a test to determine the strength of the man's wrist and fingers, and a test for the determination of blood pressure. Finally, urine and blood were examined in the usual way, and in selected cases the urine was subjected to an electrolytic test for the detection of lead, and a special test was applied to the blood to determine the resistance of the red blood corpuscles to hæmolysis (Liebermann's procedure). In judging of the results of these examinations it is necessary to bear in mind that the men were all able-bodied painters, employed at the time, or waiting and anxious to get employment.

History of former attacks of lead poisoning.

Twenty-seven men gave a history which clearly pointed to lead poisoning, that is, they told of one or more attacks of abdominal pain, constipation, severe headache with or without vomiting, lasting for several days and not accompanied by fever. Eight gave a history of the above symptoms only; the other 19 had had neuromuscular disturbances as well, such as rheumatic pains, lumbago, sciatica, anæsthesia, or paræsthesia, especially in the arms; muscular cramps, trembling and twitching of the muscles. Two had had paralysis—1 of the arms, 1 of the legs. Four had had an attack of loss of con-

sciousness and delirium, one of whom attributed it to the wood alcohol with which he was working at the time. In only one case was the delirium accompanied by fever, and in none, except the wood-alcohol case, was there any apparent cause for the attack. Ten of the 27 men had been told by physicians that they were suffering from lead poisoning; 3 more were not sure whether the diagnosis had ever been made.

Besides these 27, there was an equal number of men whose past histories were suggestive of lead poisoning but not as clearly so.

Present complaints.

Seventy men described symptoms more or less pronounced pointing to some disturbance of health, the principal ones being as follows:

Loss of strength	16
Loss of weight	12
"Nervousness"	33
DIGESTIVE.	
Nausea	16
Loss of appetite	24
Foul taste	33
Vomiting	10
Constipation	50
Diarrhea	19
Intestinal pain	43
Distention	35
SENSORIAL.	
Headache	50
Vertigo	36
Fainting	6
Insomnia	22
Depression	8
Attacks of mental confusion	8
Memory failing	22
NEUROMUSCULAR.	
Pains in the joints	24
"Rheumatism"	35
Muscular cramps	24
Tremors	17
Anæsthesia or paræsthesia, especially of arms	26
OCULAR.	
"Spots," double vision, or failing sight	30
Itching eyelids	14
AURAL.	
Ringing—imperfect hearing	40
URINARY.	
Incontinence—nocturnal frequency	38
CIRCULATORY.	
Palpitation—nosebleed	27

Fifteen of the men were evidently suffering from neurasthenia.

So far as possible, specific causes of any of the above symptoms, other than lead poisoning, meant that such symptoms were not included in the above table, i. e., (1) in cases of rupture; visceralgia, constipation, and distention were omitted; (2) neuralgias due to teeth were omitted; (3) joint pains and rheumatism due to acute inflammatory rheumatism past or present were omitted; (4) defective vision due simply to refractive errors was omitted as far as possible; (5) aural disturbances due to otitis media were omitted as far as possible; (6) urinary disturbances were in nearly all cases due to nocturnal frequency, not to venereal diseases, and rarely to incontinence; most cases were in those of advancing years; only one due to diabetes.

Physical examination.

There were abnormal physical findings, including more than simply a lead line, in 52 cases, the most significant of which are the following:

General emaciation	4
Local emaciation (arms)....(only 25 examined in this respect)	5
Prematurely aged	8
Lead line (10 not pronounced)	19
Pyorrhea (17 very pronounced)	51
Tremor of lips or tongue	27
Tremor of hands	19
Nystagmus	4
Unequal pupils	4
Arterio sclerosis (5 others suspicious)	6
Incoordination (arms)	17
Wrist reflexes (2 absent, 2 much increased)	4
Pupil reflexes (absent)	2
Heart	21
Lungs (7 emphysema; 1 acute bronchitis; no active tubercular lesions, although 14 were suspicious)	20
Enlarged liver	6
Gaseous distention	7
Gouty toe joint	8
Edema of ankles (6 with varicose veins)	7
Knee jerks (3 absent, 13 exaggerated)	16

Special tests.

1. Sodium Sulphide Skin Application.—Merely as a matter of interest, a sodium sulphide solution (5 per cent) was applied to the hand, arm, and chest of 90 of these men to see if invisible particles of lead paint were still clinging to the skin in spite of thorough washing. The sodium sulphide turns lead paint black in a few seconds, so that it serves to demonstrate even tiny particles deep down in the skin. The test showed the presence of lead paint on the hands and wrist of 42 of the 62 men who had been working in lead paint within

a week or 10 days, although in all these cases their hands and arms had been washed repeatedly. The most striking case was a man who had not worked for fully two weeks and had washed his hands at least once a day during that time, yet the black streaks appeared on his skin when the sodium sulphide was applied. The test served as a very impressive lesson to the men in the necessity for thorough washing and bathing.

2. URINARY ANALYSIS.[1]—The analysis was made from a fresh specimen in each case, and in addition most of the men, in response to a special request, brought a pint bottle of urine, which, being added to the fresh specimen, gave a sufficient quantity for the determination of lead by the electrolytic process. For this last test 29 cases were selected in which the suspicion of lead poisoning was most strong.

Albumin and casts	7
Sugar	1
Indican:	
Excessive	8
Above normal	19
Lead present (out of 29 analyses)	2

3. BLOOD.—The stained smears showed a slight leucocytosis in 5 cases, no blood diseases, no significant granulation. The Liebermann test showed 2 cases of increase of the resistance quotient of the red blood corpuscles in 21 tests carried out on selected cases. The hemoglobin never fell below 90 per cent (Tallqvist) and below 95 per cent in only 3 cases.

4. STRENGTH OF HAND AND WRIST.—This was determined by a dynamometer, which had been tested on 35 men who were not painters, to determine the average reading, which proved to be a trifle over 150. Tested on 95 of the 100 painters, the reading showed that the right hand was below normal in 41 of the 95 cases, the left hand below normal in 20 cases. Men who had had injury to the wrist were not included in the test. The strength of the wrist extensors was determined also by the dynamometer. The man was seated in an armchair, with his hand dropping down over the end of the arm of the chair. The dynamometer was then placed on the top of the hand and the man asked to raise his hand up against the physician's resistance on the dynamometer. The normal average of readings by this procedure had been found to be considerably over 30. Sixteen out of 95 painters had a decided loss of strength in the extensor of the right hand, and in 20 there was loss in the left hand.

[1] I would note that no attempts were made to ascertain the frequency of chronic interstitial nephritis from the urinary analyses, because only a single specimen or so was available and it was considered that blood-pressure determinations and the history of nocturnal frequency were more specific in determining this condition. E. R. Hayhurst.

5. BLOOD PRESSURE.—This was determined with a mercury manometer (Mercer type), using the stethoscope applied to the cubital fossa of the right arm.

Systolic pressure was taken toward the end of the examination in each case, so as to eliminate the psychical factors as much as possible and also when possible after the patient had seen the same examination done on a previous case. The cases ranged between 98 and 204 mm. Hg. as follows:

	Cases.
Below 100 mm. Hg	3
100 and below 110 mm. Hg	9
110 and below 120 mm. Hg	30
120 and below 130 mm. Hg. (5 were under 30 years)	17
130 and below 140 mm. Hg. (4 under 40 years)	17
140 and below 150 mm. Hg. (2 under 50 years)	12
150 and below 160 mm. Hg. (5 under 60 years)	6
160 and over 160 mm. Hg. (3 under 60 years)	6
Total	100

From this table it can be seen that there were 41 cases in which the systolic pressure was 130 or over, which, according to Blum,[1] if persistent, implies contracted kidneys. However, according to the stricter rule (Johnston-Lavis), that the systolic pressure should not be over the number of years of age plus 100 for adults, there are in this table 19 cases with abnormally high pressure.

Diastolic pressure varied from 62 to 112, with 15 cases over 90; 14 of these high diastolic pressures occurring in cases with abnormally high systolic pressures.

Summary

Symptoms of acute plumbism were not found in any case. Indications of chronic plumbism were found in at least 59 cases. It is not easy to summarize these records, but they fall fairly well into the following groups:

GROUP 1.—Includes 19 men who gave a clear history of previous lead poisoning (12) or a history suggestive of lead poisoning (7), were suffering at the time from symptoms of chronic plumbism, and who in addition had positive physical findings and gave positive results to one or more of the tests described above, not including, of course, the sodium sulphide test.

GROUP 2.—Includes 16 men with a clear history (7) or a suggestive history (9) of lead poisoning and who complained of symptoms of chronic lead poisoning and were found by physical examination to have signs of this disease.

[1] Blum believes that a continuously high blood pressure indicates that the person in question should be forbidden to continue working in a lead trade. (Deutsche medizinsche Wochenschrift, Lepzig und Berlin, 1912, Bd. 38, No. 14.)

GROUP 3.—Seven men with a clear history (3) or a suggestive history (4), complaining of typical symptoms and responding positively to one or more tests.

GROUP 4.—Twelve men who had no history of former attacks, but who were at the time suffering from typical symptoms and who had positive physical findings and responded to one or more tests.

GROUP 5.—Five men, 2 with a clear, and 3 with a suggestive history of lead poisoning, not complaining of ill health but with physical signs pointing to chronic plumbism and with positive response to one or more tests.

The following nine cases might be looked upon as suspicious. Five were men whose histories were suggestive and who complained of more or less typical symptoms, but physical findings and tests were negative. Two others had a history of former attacks and had marked weakness in the wrists. One man had a lead line and a suggestive history and one had a lead line and a weak wrist.

HISTORIES OF 100 LEAD-POISONED PAINTERS.

From the record of hospitals and dispensaries the histories were gathered of 100 painters suffering from acute or chronic lead poisoning for which they had sought medical care. An analysis of these histories shows clearly the fact that painting, being a skilled and well-paid trade, is not lightly abandoned because of sickness. The average length of employment of these 100 painters was 15.77 years, while the average for 186 sanitary ware enamelers had been found in a previous study[1] to be only 6 years. Twelve per cent of the painters and 20 per cent of the enamelers had been employed less than a year at the time of their sickness. The following table gives the length of employment of these painters:

Less than 1 year	12
1 to 5 years	12
5 to 10 years	9
10 to 15 years	13
15 to 20 years	19
20 to 30 years	17
30 to 40 years	14
Over 40 years	4
Total	100

Length of exposure before first attack of sickness.

1 to 6 months	15
6 to 12 months	4
1 to 5 years	8
5 to 10 years	8
10 to 15 years	8
15 to 20 years	7
20 to 30 years	3
30 to 40 years	2
Over 40 years	1
Total	48

[1] Bulletin of United States Bureau of Labor No. 104, p. 62.

The development of lead poisoning among painters is not as rapid as it is among workmen using lead who are engaged in dustier vocations, where the period of exposure before the onset of symptoms may be only a few days. Among 120 cases of lead poisoning in the white-lead industry [1] 74 per cent developed after less than one year's exposure, while the table just given shows that in only 19 per cent of the painters was this true.

A closer examination of these records shows that certain kinds of painting are responsible for more rapid poisoning than others. Of the 27 who sickened after less than five year's employment, 16 were railway car or carriage painters; 4 only were house painters. Another element that enters in here, however, is that the car or carriage painters are much more likely to be unmarried foreigners working for a low wage and therefore more likely to seek hospital and dispensary care.

Specific statements as to whether the attack suffered from was or was not the first attack of lead poisoning was given by 74 of these 100 painters. Fifty had suffered more than once.

1 attack	24
2 attacks	23
3 attacks	5
4 attacks	2
5 attacks	2
6 attacks	2
"Many" or "several"	16
Total	74

It is evident that men vary greatly in their resistance to lead poisoning. Twelve had their first attack within three months of beginning to work, but on the other hand there were 6 who had worked more than 20 years before they were aware that they were poisoned, before their first acute attack of plumbism. It is well to mention the fact that all of the 19 painters who sickened in less than a year's time had been working inside and using sandpaper.

The following is a brief summary showing the character of the disease from which these painters suffered:

Acute gastric type without complications	33
Gastric with complications	49
No gastric symptoms:	
Nervous only	7
Arthralgia or myalgia [2]	4
Myalgia and palsy	3
Arteriosclerosis	3
Arteriosclerosis with palsy	1
Total	100

[1] Bulletin of United States Bureau of Labor, No. 95, p. 224.

[2] It was not always possible to tell from the history sheet whether the pains were in the joints or in the muscles.

The complications were as follows:

Palsy (5 slight, 14 involving more than one limb)	39
Encephalopathy (transient acute, 6; mental deterioration, 3)	9
Eye disturbances	11
Arteriosclerosis with chronic nephritis	8
Arthralgia or myalgia [1]	24

As palsy is usually one of the later symptoms of lead poisoning, one would expect that the proportion of palsied men would be greater among painters than among men who sicken more quickly and remain a shorter time in their employment. When we compare the proportion of cases of palsy found among 177 lead-poisoned enamelers, whose records were studied, with the figures given above, we find that the enamelers had only 15.9 per cent, while for the painters it was 39 per cent. The painters had also 9 per cent of encephalopathy, as against 4 per cent among enamelers.

Twenty-seven of the 39 palsied men told how long they had been employed before they became paralyzed. It was less than 10 years in 7 cases, between 10 and 20 years in 5, and 20 years or over in 15. The three that had the shortest exposure were two railway-coach painters and one ship painter, both of them occupations which involve dry sandpapering.

The occupations in which the 100 men were engaged are not very important, as they would be different in different cities. Chicago is, however, fairly typical in the proportion of men employed in the various kinds of painting.

The occupations of the 100 painters were as follows:

House painting	56
Carriage and automobile painting	24
Railway car and street car painting	12
Iron painting	4
Sign painting	3
Ship painting	1

REGULATIONS GOVERNING USE OF LEAD PAINTS IN EUROPEAN COUNTRIES.

During the past 20 years the Governments of France, Germany, Belgium, Switzerland, and Austria have made more or less exhaustive inquiries into the dangers to which painters are exposed through the use of lead paint, inquiries which have resulted in recommendations for legislation to guard against these dangers.

Radical measures looking toward the suppression of white-lead paint have been adopted in France, but they do not come into force until January 1, 1915. The French law prohibiting the manufacture or importation of white lead and prohibiting the use of white-lead

[1] It was not always possible to tell from the history sheet whether the pains were in the joints or in the muscles.

paint was strongly backed by the medical profession in France, and physicians in Great Britain, Germany, Switzerland, Belgium, and Austria have also urged the prohibition of the use of white-lead paint. The commercial interests involved have as strenuously opposed such measures, although they have expressed themselves as not opposed to sanitary regulations looking toward the elimination of preventable causes of lead poisoning.

In February, 1911, the British Parliament authorized the Home Secretary to appoint two departmental committees to investigate (*a*) the danger attendant on the use of paints containing lead to the health of the persons engaged in painting buildings, and (*b*) the danger from the use of lead compounds to the health of the persons engaged in painting, enameling, and varnishing coaches and carriages. The reports of these committees have not yet been made public.

Following is given a brief résumé of the essential features of the laws and regulations in regard to the use of white-lead paints in leading European countries. Great Britain is omitted from this summary, inasmuch as it has not yet brought house painting under legislative control.

LAWS AND REGULATIONS IN REGARD TO THE USE OF WHITE-LEAD PAINTS IN EUROPEAN COUNTRIES.

GERMANY.—Hand mixing of white lead is forbidden. In case of other colors use restricted to small quantities by male workers over 18 years. The rubbing of fresh paint or old paint with sandpaper or pumice may be done only after previous dampening. Workmen who come in contact with lead colors or lead mixtures must be instructed as to the dangers to their health and furnished with leaflet containing protective regulations. Employers must see that workmen coming in contact with lead provide themselves with caps and work clothes and that they are used during work. Facilities for washing, soap and towels, and brushes for the cleaning of hands and nails must be provided. Lunch rooms also must be provided. Medical examination at least once every six months is required.

FRANCE.—White lead must be used only in the form of paste in the workshops of house painters. Products containing lead as their basis must not be used with the hands. Scraping off or rubbing by means of pumice stone of white-lead paint in a dry state is prohibited. Where white-lead paint is removed by the wet method, employers must place at the disposal of workmen overalls, and see that they are worn. The overalls must be kept in good order and frequently washed. All necessary facilities for washing must be provided at the place where the work is carried on. A decree containing the regulations must be posted in the place where new hands are taken on and where workmen are paid. Medical certificates are required, which must be renewed every three months. Lunch rooms must be provided. The law of July 20, 1909, to come into effect January 1, 1915, absolutely prohibits the use of white-lead paint for exterior or interior painting.

BELGIUM.—Belgium requires that the workmen avoid contact with the white lead with their hands, apparently not forbidding hand mixing or mixing by handwork. The posting of notices in establishments where dangerous or unhealthy conditions exist is a general requirement of the Belgium factory law. Dry rubbing of old paint is forbidden. Medical examination every three months is required. Wash and lunch rooms are required.

AUSTRIA.—All hand mixing of white lead is prohibited. In case of other colors the hand mixing is regulated. Dry rubbing of fresh paint or of old paint is prohibited. The use of white lead in inside work is forbidden except in certain cases. Paints containing white lead must be labeled so as to show that fact. Workmen must be instructed as to the dangers of their employment. Medical examination is required every three months if over 20 painters are employed, and under the same conditions wash and lunch rooms must be provided.

Austria's prohibition of white-lead paint in interior use carries with it several exceptions: On old white-lead paint, when nothing else would adhere well, white-lead paint may be used. It may also be used on walls which will be exposed to the action of steam or vapors and in cases where the use of this paint would be required to keep work from going outside of Austria. All old lead paint which has been rubbed or scraped off by the moist process prescribed must be gathered up from the floor before it has had time to dry.

In Germany, France, and Austria the law is stricter for painting in factories than for house painting. For the former there are specific regulations much like those in the other lead trades. Working clothes must be provided, alcohol and tobacco are forbidden, there must be medical inspection every six months, and the lavatory facilities must include soap, towels, brushes, an adequate number of basins, and warm water. Germany has, however, provided more carefully for the protection of house painters than has Austria. In Germany, if the work is house painting, the contractor is required to provide overalls and caps for the men and must have these articles washed and kept in order. He must provide a place sheltered from the cold, where the men may leave their street clothes and where they must keep and eat their lunches, and this place must have soap, towels, warm water, washbasins, and nailbrushes. No other country has yet made such detailed provision for the care of house painters. It is also made the duty of the employer in Germany to suspend from work any painter whom he knows to be suffering from lead poisoning.

The laws in these countries insist also that proper precautions shall be taken by the men themselves. Painters are forbidden to leave the premises where they are employed without first thoroughly washing their hands and faces. No food, no beverages, no tobacco, may be carried into the workroom, and the men are not allowed to take their lunches in any room except the one provided for that purpose.

POSSIBLE LEGISLATION FOR THE PROTECTION OF PAINTERS IN THE UNITED STATES.

In the United States there has been, curiously enough, little discussion of the question of lead poisoning among painters till very recently. After the publication of the Illinois report referred to

above, a law was passed for the protection of workers with lead and its salts, but this law covers painters only when they are employed in factories and workshops, not in house or sign painting. No other State has any special law governing the lead trades,[1] and even the Illinois law is inadequate.

Throughout this report, whether dealing with American or European conditions, we have found again and again that the greatest danger in the use of lead paints comes from the dust caused by dry rubbing. Germany, Austria, France, and Switzerland have forbidden dry rubbing for all kinds of work; Belgium has forbidden the rubbing of old paint. In this country many objections are urged against the use of pumice and water on the ground of injury to the surface, increased expense, and so on, but these objections do not apply to the use of oil with sandpaper in order to keep down the dust. It does not seem unreasonable to insist that American painters should be protected against the danger of dry rubbing and that if paint must be sandpapered, the use of some oil to moisten and catch the dust should be required.

When it comes to providing properly for the sanitary needs of the painter in both factory painting and house painting, there seems no reason why the American employer or contractor should not be required to do as much as the German or French or Austrian. The Illinois law already provides for the protection of factory painters, and the Brotherhood of Painters, Decorators, and Paper Hangers has recently insisted that the same protection be extended to house painters. During a recent strike in April, 1913, the following demands were made by the brotherhood:

> No workman or apprentice shall be required to use any poisonous material or material injurious to the health, such as wood alcohol, varnish remover, oxalic acid, or the sanding of lead, etc., unless they are protected with respirators, gloves, etc., same to be furnished by the employer; nor shall they be required to use any dirty or insanitary waste, rags, or drop cloths. There shall be an allowance of five minutes for wash time in each four hours' work, and where lead or other poisonous material is used, the employer shall furnish hot water, soap, and towels to the workmen. The officers and members of the organization shall enforce this clause.

This is said to be the first time the union has effectively dealt with health questions, and in all probability the inquiry quoted above in regard to occupational diseases among the members of the brotherhood in Chicago had much to do in calling the attention of the trade to the importance of such measures of disease prevention.

European laws emphasize the need of instructing painters in the dangers of their occupation, and giving them simple directions as to

[1] A law for the prevention of occupational diseases with special reference to lead poisoning was approved in Ohio May 6, 1913, but it applies only to the manufacture of white lead, red lead, litharge, sugar of lead, arsenate of lead, lead chromate, lead sulphate, and lead nitrate or fluosilicate.

how to avoid these dangers. In this country the need for such instruction is most apparent in factory and shop work where untrained men are employed, many of them foreigners with little knowledge of English. This is provided for in the Illinois law.

However, it is not of much use to warn men against the dangers of certain substances in paint unless they know whether or not the paint they are handling contains these substances. Therefore, the paint-labeling laws which have been advocated for the protection of the buyer are desirable as a protection for the user of the paint as well.

When it comes to the question of prohibiting the use of white lead paint for inside work there is a difference of opinion. At the 1910 meeting of the International Congress of Industrial Hygiene in Brussels, the question of prohibiting white lead paint altogether was discussed, and the majority of the speakers regarded this as radical and premature, but saw no valid reason for continuing to allow its use in interior work. As we have seen, Austria has prohibited it. The step was taken after a careful investigation had been made into the comparative dangers of inside work and outside work with lead paint. It was found that the cases of lead poisoning among inside painters were out of all proportion to the amount of lead used, for less than one-quarter of the white and red lead paint used in Austria was on inside work. Only 2,750 q. were required for inside work as against 9,500 q. for outside work.[1] In Vienna in one year's time 163 cases occurred in connection with the use of 1,600 q. of lead colors on the inside and on the outside where 9,500 q. were used, only 80 cases.

With the exception of France, no other country has thus far followed Austria's example, although the Federal Council of Switzerland in 1908 advised the adoption of similar restriction in the use of white-lead paints, and the Cantons of Basel and Zurich have followed this advice.

The question was put to 100 intelligent union painters, and all but one of them declared themselves in favor of the substitution of zinc white for lead paint in inside work, because of the danger attending the use of lead paint. E. F. Ladd, dean of the department of chemistry and pharmacy of North Dakota Agricultural College, a well-known authority on paint, when consulted on this point answered as follows:

I would limit the use of white-lead paint, not permitting its use in general for interior painting, although I do not know that I would say that white lead should be excluded from all classes of interior painting. I would not at this time exclude the use of white lead from exterior painting. Restrictions in the use of white lead should not

[1] In 1904 and 1905, the paints used in inside work in Austria were 23 per cent white lead, 62 per cent zinc oxide, and 15 per cent lithopone. The same publication gives the quantities of these paints used in Germany in 1903, quoting from a report of the Düsseldorf Chamber of Commerce. For inside work, white lead 38 per cent, zinc white 35 per cent, lithopone 15 per cent.

be confined to that alone, but should apply to all classes of lead paint that are possessed of toxic properties. I would, unless information that I do not now possess, can be furnished, prohibit the dry rubbing down of white lead, but permit the use of pumice and water or sandpaper and some drying oil. I would restrict the use of dry white lead to be handled by painters; it is not necessary, for the work can be done better in the factory. I would have every paint of this kind labeled to show its true composition in such a way that everyone can understand its essential features. I would also have an educational campaign carried on warning painters of some of the dangers of carelessness and telling them of remedial methods to prevent lead poisoning.

SUMMARY.

Paint consists essentially of pigment ground in a liquid vehicle, and either the pigment or the vehicle may possess poisonous properties.

The most important liquids used as ingredients of paint or of paint removers are linseed oil, turpentine, petroleum, benzine or naphtha, and benzole. Wood alcohol and fusel-oil products are also sometimes used. These are all volatile poisons except linseed oil.

The dangerous pigments are the different salts of lead, the basic carbonate, red lead and orange mineral, the chromate, and the basic sulphate.

Experiments with the basic carbonate and the basic sulphate show that the former is much more soluble in human gastric juice than the latter and causes more rapid and severe poisoning in animals.

The danger in the use of leadless paints and of paint removers comes from the liquid vehicle and is increased by lack of proper ventilation. If quickly drying, flat finish paints are used in close, ill-ventilated rooms, serious poisoning from the fumes of coal-tar products and of turpentine may result.

The danger from the use of lead paints comes from paint dust in the air and from paint smeared on the hands which may be carried into the mouth with food or tobacco.

Paint dust is caused chiefly by rubbing old or new paint with dry sandpaper. This process is universally recognized as the most dangerous part of the painters' trade. It could be completely done away with by the use of cheap mineral oil to wet the sandpaper and catch the dust.

The protection of the painter against poisoning through unwashed hands can be effected only by providing adequate washing facilities and a clean lunchroom wherever work with lead paint is carried on.

Interior house painting, ship painting, and certain kinds of carriage painting, including railway cars, are the most dangerous branches of the trade in the United States.

92589°—13——5

The painters' trade is regarded in all countries as the most important of the lead industries. Six European countries have carried on investigations in the use of lead paint in industry, and five have recommended legislation more or less comprehensive to lessen the dangers to which painters are exposed. In the United States, Illinois alone has passed such a law, and it does not cover any painting except that done in workshops.

A study of hospital reports from four cities shows that one-fourth of the hospital cases of lead poisoning in these cities were painters. In New York City the proportion is even greater. Forty of 60 fatal cases of lead poisoning in New York were painters.

Among 1,009 painters in Chicago who sent answers to a list of questions, 185 gave a history of lead poisoning, 72 of kidney trouble, 77 of rheumatism, and 24 of stomach trouble.

One hundred able-bodied painters presented themselves for physical examination by a specialist in occupational diseases, who found that 59 of them showed evidence of chronic lead poisoning.

An analysis was made of the hospital or dispensary histories of 100 lead-poisoned painters. The proportion of complicated and of chronic cases was large, over half had had more than one attack, 39 had had palsy, and 9 had had brain symptoms.

This study of the painters' trade in the United States shows that there are many elements of danger, most of them avoidable, and it shows that if protective legislation is to be passed it should be directed toward the prevention of poisonous fumes and dust, and the provision of facilities for bodily cleanliness.

Such legislation should (1) forbid the use in unventilated rooms of paints or paint removers containing volatile poisons; (2) forbid dry sandpapering or dry chipping off of lead paint; (3) insist that the employer provide a proper place for his workmen to hang their street clothes and keep and eat their lunch, and a washroom with a sufficient number of basins, warm water, soap, towels, and brushes; (4) require the labeling of all paint offered for sale in such a way that the painter can be apprised of the danger involved in its use; (5) in the case of work done in factories, cards of instruction for the workmen should be posted, and if necessary these should be written in one or more foreign languages.

The total prohibition of lead paint for use in interior work would do more than anything else to improve conditions in the painting trade.

INDEX.