BULLETIN 41

The Toxic and Antiseptic Properties of Paints

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SCIENTIFIC SECTION
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PART I

Composition and Toxicity of Oil Paint Vapors

In a paper entitled "The Composition of Paint Vapors,"* the writer has recently published the results of an extended research into the character of the volatile vapors given off by various paint materials. This work was originally designed to determine whether the fumes evolved from drying white lead paint, contain volatile lead compounds which, if inhaled, might cause lead poisoning. The tests, however, proved that paint vapors do not contain metallic ingredients and are therefore not to be held accountable for cases of lead poisoning from which painters may suffer.

The most important outcome of the tests was the discovery of carbon monoxide in the vapors from drying paints. Since this substance is an extremely poisonous gas, it is quite fair to assume that its inhalation in unventilated rooms which are being painted, constitutes the real cause of that peculiar type of anaemia from which painters sometimes suffer.

In the tests referred to, the interior of metal and glass cylinders were painted with various oils and oil-pigment paints. The air entering the cylinders was first purified and then passed over the painted surfaces. The air was then withdrawn and passed through various solutions to absorb its different constituents. By this means, an exact determination was made of its composition. The results of the tests are summed up in the following conclusions:

Summary of Conclusions

1. When linseed oil or similar drying oils are spread in thin layers, the absorption of oxygen which takes place is accompanied by the evolution of considerable amounts of carbon dioxide and organic substances. Carbon monoxide is also evolved in small amount.

2. Oil paints containing lead or zinc pigments do not emit volatile compounds of a metallic nature.

3. Drying paints evolve water-soluble acid substances, such as formic acid, as well as acid substances which are apparently of a fatty nature. Carbon dioxide and carbon monoxide are also present in the vapors from the drying paint. The type of pigment used in the paint may directly affect the amount and character of the volatile substances produced. Basic pigments apparently stimulate the evolution of such products.

4. Aldehydic substances are present in the vapors from drying oil paints. These substances probably have a marked bactericidal effect upon pathogenic bacteria, thus accounting for the sanitary value ascribed to oil-pigment paints.

Since the above experiments were reported, the writer has had occasion to determine, in a more satisfactory manner, the composition of oil vapors. The tests were made in the "scrim" room of a large lino-

* Jour. Indus. & Engrg. Chem., Vol. VI, No. 2, Feb., 1914.

lenn factory where thousands of yards of cotton scrim are suspended in the air and repeatedly coated with linseed oil. As soon as one coat becomes dry, another flowing coat is applied, and the process is repeated for several weeks until a semi-transparent rubber-like mass of oxidized oil, ¼ inch thick, is formed on either side of the scrim. In this room was placed an open tin can containing a pint of ordinary tap water. After exposure to the vapors in the room for a week, the can was removed to the writer's laboratory and the contents examined. The odor of the water was very strong and suggestive of acrolein. A considerable quantity of suspended and precipitated red oxide of iron was observed. As the water originally contained iron, it is probable that its precipitation was due to the carbon dioxide given off by the drying oil. Analysis of the water showed the presence of appreciable quantities of formic, acetic and butyric acids. Aldehydes were also found present.

A consideration of the previously cited laboratory tests in which the writer discovered the presence of carbon monoxide in the vapors from drying oils and paints, will no doubt be of interest to medical authorities. The results will probably throw considerable light upon cases of poisoning which have been attributed to lead absorption, but which were possibly due to the effect of carbon monoxide upon the red corpuscles of the patient. Symptoms such as sallow complexion, general lassitude, emaciation and incoordination, caused by the inhalation of carbon monoxide over long periods of time, might easily be mistaken for symptoms of lead poisoning. When a painter, suffering badly from such symptoms, appears before a physician and informs him of the character of his work, the physician is very apt at first to diagnose the case as suspiciously like plumbism. Unless further examination be made, treatment for plumbism might be resorted to.

That great credence has been placed in the theory that white lead paint gives forth poisonous metallic vapors, is shown in the following citations from an article written by one of the most prominent medical men of the age:

> There is still considerable difference of opinion as to what takes place when men and animals who have breathed the emanations given from a surface freshly painted with white lead suffer in consequence. In my book, Diseases of Occupations,* I draw attention to the fact that during the preparation and mixing of paints, peculiar symptoms are occasionally complained of by the men which are not altogether due to the white lead present, but to some peculiar condition of the linseed oil. Prof. Baly, of Liverpool, on spectroscopic examination of a beam of light passed through the emanations given off by a freshly lead painted surface, was at first disposed to regard the harmful character of these exhalations as due to lead, but further experiments convinced him that, as similar emanations are given off by linseed oil mixed with manganese dioxide, they are due to unsaturated aldehydes, arising from hydrolysis of the linseed oil. These emanations are given off more readily from surfaces painted with white lead than where zinc white has been used. They vary with the percentage of linseed oil and they are given off in descending proportions according to whether white lead, sulphate of lead, or zinc white has been the compound added to the oil. Baly is therefore disposed to regard the aldehydes evolved from freshly painted surfaces as the harmful agent and not the lead. This, however, can only be partly true. That lead emanations are also given off is more than a probability, for only thus, among other reasons, can I explain the occurrence of extreme anemia, a blue line on the gums, and the presence of a small quantity of lead in the urine of a previously healthy young medical man recently under my care, who became seriously ill through living and sleeping at home when all his rooms were being painted. Besides, the experiments of Mm. Heim and Hebert show that lead is present in the vapor given off from painted surfaces, and that to this circumstance the plumbism of house and coach painters is due.
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> (Excerpt from "Industrial Lead Poisoning and Some of the Problems it Raises," Sir Thos. Oliver, M. A., M. D., LL.D., D. Sc., F.R.C.P., Newcastle-upon-Tyne. Trans. XV. Internat. Congr. Hygiene and Demog., Vol. III., 826.)

At one time the present writer was disposed to place full confidence in the theory that lead paints evolve metallic vapors. His recent experiments have, however, afforded sufficient data to dispose of such a theory. Lead is not a metal which forms easily volatile compounds. Arsenic and antimony are the only metals which afford vapors at ordinary temperatures, the hydrides of these metals being well known and of a very poisonous nature. Antimony is often present in pig lead, and it is quite possible that the lead used in corroding the pigment for Baly's tests contained traces of antimony. It is possible that sufficient vapors were produced from this metal to account for the extremely delicate spectroscopic tests which were reported, providing the results obtained were really due to metallic vapors.

It is apparent that many other cases of lead poisoning have, without justice, been attributed to the vapors from white lead paint. The writer once heard of a case of lead poisoning, in which the patient (a woman) had contracted the disease while boiling out some old white lead paint pots which had been left by a painter. The patient, who was of an extraordinarily robust nature, lost weight, became sallow in appearance, and developed a well marked lead line on her gums. She, of course, attributed the poisoning to the breathing of lead fumes from the paint pots. It is probable, however, that she scraped the interior of the pots to clean them, and in so doing had collected considerable lead under her nails and in the pores of her skin. Possible failure to clean her hands properly before eating would account for the effects which followed. It is also possible that she possessed an idiosyncrasy to lead, which made the cutaneous absorption of a small quantity sufficient to cause poisoning.

A case of lead poisoning has been referred to by Klein* in citing a discussion of Baly's paper, where a young lady, the daughter of a physician, became seriously ill. A marked changed was noted in her blood corpuscles. Her father had attended many lead workers and had observed a similar change in their blood when they became poisoned with lead. It was later ascertained that the young lady had

* Diseases of Occupation. Methuen & Co., London.

* Behavior of Paints under the Conditions of Practice. Armstrong & Klein J. S. C. I. No. 7, Vol. XXXII, Apr. 1913.

occupied a room freshly painted with white lead. The father probably attributed his daughter's illness to the absorption of lead fumes from the drying paint. Klein, however, points out that the change noted in the blood corpuscles was probably due to the breathing of turpentine fumes emitted by the paint, and he describes a very simple test which he thinks might give relative results in determining the effect of various drying substances upon the blood corpuscles. He utilizes the leaf of the Japanese laurel, which turns black when placed in contact with the vapors of turpentine, benzine or similar solvents.

The present writer is convinced that the change in the blood corpuscles of a person who has breathed the fumes of drying paint in an unventilated room, is more likely due to the effect of the carbon monoxide evolved by the paint. The use of turpentine doubtless stimulates the oil present to give off larger quantities of such gas, but the effect of turpentine should be cited as a contributory effect in this respect.

Carbon monoxide, if present in appreciable percentage, is really the most poisonous constituent of the vapor from drying paint. The physiological effect of this gas is ably set forth in Bartley's Medical Chemistry, page 193, as follows:

> "*Physiological Effect of Carbon Monoxide:* It has the power of combining with the hemoglobin of the blood and of expelling the oxygen. It thus acts as a narcotic poison; causing dizziness, headache, nausea, incoordination of movements, convulsions, and death. If the carbon monoxide be in sufficient quantity to saturate all the hemoglobin, recovery seldom takes place. The blood has a light red color and does not coagulate after death, or decompose as readily as normal blood. * * * If the hemoglobin is only partially saturated, recovery may take place, but very slowly, debility, anæsthesia, etc., remaining for days. Air containing 0.5% kills birds in three minutes; 2.0% renders a guinea pig insensible in two minutes. Artificial respiration is of little use. Transfusion of blood or intravenous injection of sterilized salt solution, 0.7%, is the most promising treatment. The sources of danger are open fires, defective draft in chimneys, escape of coal gas and especially "water gas" from defective fittings or from leaks under the ground. When the ground is frozen and the gas escapes into the soil near a dwelling, the gas diffuses through the ground into the cellar, and, as it is thus deprived of its odor, persons may be poisoned and not know where it comes from. Illuminating gas poisoning is essentially a poisoning by the carbon monoxide which it contains. Suffocation is not very different from suffocation by other gases, and should be distinguished from poisoning."

In a paper bearing upon the hygiene of the iron and steel industry, Darlington[*] points out the danger to workmen breathing carbon monoxide produced in "salamander" grates, as follows:

> "The chief danger to workmen is from the inhalation of carbon monoxide. When we breathe, a certain quantity of oxygen is taken into the lungs, passes into the blood and is carried by the red material of the blood to the various tissues of the body, where it is used for the production of heat and energy. The red material of the blood here gives up its oxygen, and the blood takes up carbon dioxide and carries this to the lungs from which it is exhaled.

[*] The Heating of Iron & Steel Plants. Thos. Darlington, M. D. Vol. I, No. II, Bull. Amer. Iron & Steel Institute, p. 323.

> "Carbon monoxide has a greater affinity for the red material in the blood than has oxygen, making a more stable combination. The deleterious effect of carbon monoxide is due to this tendency of combination with the red material in the blood, which reduces its oxygen-carrying power. Except in closed rooms, there is no immediate marked effect upon the workman, because the gas diffuses rapidly in the atmosphere. But the frequent breathing of even a small amount of the carbon monoxide will in time produce anæmia. This statement is not made upon actual experiment but on clinical experience. If the air contains more than one percent of carbon monoxide, it may prove quickly fatal."

The master painter may be relieved to learn from these references that paint is not the only source of carbon monoxide. Nevertheless, he will probably be impressed with the poisonous nature of this gas. It is quite certain that the amount of such gases evolved by a drying paint is insufficient to act fatally, but the painter should remember that the development of such gases is always accompanied by the absorption of oxygen from the air by the drying oil. Atmospheres are thus devitalized and rendered less capable of supporting life. A very interesting calculation may be made to show the effect of a drying paint upon the atmosphere of a closed room. The figures which are recorded below are made upon the assumption that the paint used will dry perfectly at the end of forty eight hours.

In a living room twenty feet square and ten feet high, there is approximately 1200 square feet of wall and ceiling area, and the air content of the room is approximately 4000 cubic feet. Air weighs 30.5 grams per cubic foot, and contains approximately the following constituents:

Nitrogen	78.0%
Oxygen	20.03%
Water	.84%
Carbon Dioxide	.04%

The actual amount of oxygen present in the air of such a room would therefore be 30,000 grams (approximately 66 lbs.). To cover the walls and ceilings of the room, there would be required three gallons of paint which would spread at the rate of four hundred square feet per gallon. Paints weigh approximately 15 pounds to the gallon, and contain, on an average, 66 2-3% of pigment and 33 1-3% of oil. The 3 gallons of applied paint would therefore contain approximately 15 lbs. of oil. If this oil takes the theoretical amount of oxygen required for proper drying, namely 15% of its weight, there will be absorbed 2¼ lbs. of the 66 lbs. of oxygen present in the air. Incidentally, the linseed oil may have evolved 2¼ lbs. of water and ¾ lb. of carbon dioxide as well as smaller percentages of carbon monoxide, aldehydes, fatty or aromatic acids, etc. The air content of the room, therefore, would probably show on analysis the following:

Nitrogen	78.31%
Oxygen	19.89%
Water	1.53%
Carbon Dioxide	.27%
	100.00%

A very simple preventive for such conditions as have been pointed forth in the above discussion, may be had by supplying ventilation to a room during painting. Painters working in well ventilated rooms have probably never suffered discomfort from the vapors of oil paint of any type. Foremen should therefore always insist upon proper ventilation whenever painters are at work.

One of the most important features connected with the formation of vapors by drying paints, is that which relates to the germicidal properties of such vapors. Foreign investigators have shown that the vapors from oil paints are very active in retarding and preventing the growth of bacteria. Tests made by the writer have also shown marked antiseptic properties of paints.[*] Some tests conducted recently by the writer have shown that the vapors from oil paints are extremely energetic in destroying bacilli. These tests were made in the following manner:

Three small porcelain crucible covers were sterilized at 120° C. in an autoclave. They were then filled with sterile melted lactose agar and the agar allowed to solidify. The agar in each cover was subsequently cross streaked with a platinum needle, previously dipped in a culture of B. Coli Communis (of the Colon Typhoid group). The covers were then suspended by wire from the center of stoppers inserted into large glass tumblers. All of the apparatus was first sterilized before using. The first tumbler was left empty, as a blank test. Into the second tumbler was placed 3 c.c. of 40% formaldehyde solution. *Into the third tumbler* was placed a half ounce of oil paint. This tumbler was revolved in order to distribute the paint over the interior surface and sides. The three sets of apparatus were placed in an incubator at 37° C. and allowed to remain there for 24 hours. When removed, the agar cultures were examined and photographed. In the blank test (Tumbler No. 1), a marked growth of bacilli was shown on the surface of the agar where it was inoculated by the needle. The agar in Tumbler No. 2 showed no development of bacilli. The fumes of the formaldehyde, on account of their antiseptic action, had prevented the growth of the Coli. The agar in Tumbler No. 3 also showed no distinct growth of bacilli. The fumes of the drying paint had acted apparently with almost as much vigor as the formaldehyde.

The writer is therefore fully convinced from these tests that the most efficient means of destroying bacteria in quarters previously occupied by persons suffering from contagious disease, is to be had by painting the rooms with an oil-pigment paint. During the painting the rooms should be well ventilated, but immediately afterward they may be closed for a day or so, in order to allow the fumes from the paint a thorough opportunity for asserting their antiseptic effect upon every portion of the walls, interior and contents of the room. Fumigation with burning sulphur or washing the old paint with liquid antiseptics are probably no more efficient from a sanitary consideration, and assuredly less productive of pleasing results from a decorative standpoint than the application of a fresh coat of paint to the walls and

[*] "The Sanitary Value of Wall Paints," by Henry A. Gardner. Bull. No. 2, The Institute of Industrial Research.

...of a room. Flat wall paints made of non poisonous lithopone and ... pigments, on account of the ease with which they may be applied, ... low cost and their ability to hide surfaces with few coats, make ... especially fitted for this purpose.

PART II

Cause and Prevention of Toxic Effect of Pigments

Trade papers have recently published many articles regarding lead poisoning, and the subject has been discussed at length by master painters both here and abroad. There can be no doubt that painters have suffered to some extent from this disease, but recorded evidence shows that the majority of cases have occurred in factories where lead products are made. A historical review of the subject will show that the hand mixing of dry lead pigments is fraught with danger. It is apparent, however, that the painter who handles prepared paint products does not come in contact with lead dust, and his trade is therefore a safe one, free from the dangers that attend the older methods and materials.

Eminent authorities have pointed out that the inhalation of dry dust containing metallic particles floating about, constitutes the most dangerous source of lead poisoning; respiratory absorption being readily accomplished under such conditions. This, of course, calls for the elimination of dust as far as possible in the painting trade. The dangers from cutaneous absorption or from gastro-intestinal absorption, which are in most cases caused through uncleanliness of hands or face, will, of course, be reduced when more cleanly and sanitary conditions are provided, and when the rules of hygiene are more strictly observed.

The susceptibility of certain persons to metallic poisons should make such persons exert extreme care in handling lead pigments, while the same precaution should not be neglected by those workmen who are supposed to exhibit a great degree of resistance or tolerance to metallic poisons. In the latter class, the resistance to lead may be due to its elimination from the system in sufficient quantity to equalize the amount daily absorbed. It has been observed by medical authorities that workers in lead who are thus constituted, often feel that they are free from the effect of lead, whereas, as a matter of fact, their systems may contain a considerable amount of the metal, which upon the first provocation, induced possibly by over-indulgence in alcohol, may become active and cause fatal results.

Some danger from lead poisoning may attend the removal of old lead paints. Upon battleships it is customary to use for this purpose, wide steel chisels driven by compressed air. Piled up coatings ¼ inch in thickness are easily and rapidly removed by this method. There is formed during the operation, a considerable amount of dust contain ing a large percentage of white and red lead. The workers are, however, only allowed to carry on such work for short periods of time. During the interim, they are placed at less dangerous tasks. In this connection it may be of interest to cite the fact that red lead as a primer for steel ships is being replaced to a great extent by sublimed blue lead which, on account of its less poisonous nature and highly rust inhibitive properties, is to be highly recommended for the purpose.

Differences of opinion have been expressed regarding the danger of removing paint from an old painted surface by means of a torch. This method is not used at the present time, to such an extent as formerly, on account of the efficiency of liquid removers. The old torch process, however, is more economical and therefore necessary in some instances. The strong heat of the torch and the presence of dried oil and other organic substances will cause lead paints to be partially reduced as metallic lead. The temperature, however, is not as a rule sufficiently high to cause the formation of metallic vapors of lead. If the paint is made of zinc oxide or lithopone (this is not always possible or practical) there is much less danger, for these pigments are not materially affected by the heat of a torch. Moreover, zinc vapors are not nearly as poisonous as lead vapors. The truth of this statement is shown by the following excerpts from articles relating to the toxicity of zinc compounds:

"Of 67 cases of zinc poisoning collected by Wuthause, 30 were in Great Britain and only 3 in the United States. All were caused by two salts, the sulphate and the chlorid. The sulphate was to blame in 18 cases, of which 8 were due to mistaking it for Epsom salt."

Text Book of Legal Medicine and Toxicology. Peterson & Haines, Vol. II, p. 443.

"The poisonous action of zinc oxide is so weak that it is almost doubtful whether it should be considered a poison. Dr. Marcet has given a pound (453.6 grams) during a month in divided doses with out injury to a patient afflicted with epilepsy, and the workmen in zinc manufactories cover themselves from head to foot with the dust without very apparent bad effects. It is not, however, always innocuous, for Popoff has recorded it as the cause of headache, pain in the head, cramps in the calves of the legs, nausea, vomiting, and diarrhoea, and he also obtained zinc from the urine of those suffering in this manner. Again, a pharmacy student filled a laboratory with oxide of zinc vapor, and suffered from well marked and even severe poisonous symptoms, consisting of pain in the head, vomiting and a short fever."

Poisons: Their Effect and Detection. A. Wynter Blyth, pp. 680 and 681.

"Brass founder's ague may be defined as an acute malaria-like syndrome of chill, fever (sometimes) and sweats appearing a few hours after the inhalation for a few minutes or longer of the vapors

The so-called zinc fever has only been noticed in the founding of brass; it is always preceded by marked dryness; the other symptoms being similar to those described.

or fumes arising from molten brass or from the fumes of pure zinc alone* affecting only or mostly those unaccustomed to such exposure."

Excerpts from "Occupational Brass Poisoning: Brass Founder's Ague." Dr. Emery R. Hayhurst, Chicago, Ill. Trans. Internat. Cong. Hygiene and Demog., Vol. III., 706 and 707.

"In many cases large doses of the salt (zinc sulphate) have been administered for days without any symptom of toxic effects. In one instance 30 grams of salt were given three times a day for six weeks without the appearance of any symptoms of poisoning. All writers on toxicology, however, agree that in certain quantities zinc salts exercise a poisonous effect."

Page 33, "Zinc in Evaporated Apples," by Harvey Wiley, Bulletin No. 48, Division of Chemistry, U. S. Dept. of Agriculture, 1896.

Lead workers and painters may be interested to know that a method[1] has recently been proposed for the removal of lead from the system by means of an electral bath, the legs of the patient being partially immersed in a dilute electrolyte, which, on the passage of the proper amount of current would remove the metallic poison from the system. Although such methods may prove of great value in the treatment of lead poisoning, it is much better for lead workers to use preventive measures which will guarantee their safety from lead.

It is pleasing to note that corroders are already alive to the value of preventive measures, and the factories of the country are all adopting safety appliances and devices which are of great merit for this purpose. In a recent article,[2] the resident surgeon of a large white lead works states:

"Dust is the curse of the lead industry for its minute particles are surrounded by a layer of moisture which renders them more liable to absorption by the respiratory mucous membrane, so it is essential that dust in the various processes of manufacture be eliminated. Every effort has been made to accomplish this all important factor. Our chasers are enclosed in heavy cast iron dust proof covers from which leads a flue with a powerful suction of air which carries all dust to one of the main organ pipe dust collectors.

"Dry sweeping is not allowed, and the rooms are gone over each day with a vacuum cleaner, which thoroughly cleans them without the creation of any poisonous dust to contaminate the atmosphere."

The above citation indicates the great care which is exercised to prevent the absorption of lead dust in factories. Should we not exercise similar care in guarding against lead dust in our public buildings? Many tons of corroded white lead flatted with turpentine were at one time applied to the walls and ceilings of school rooms and hospitals. Gradual disintegration of such paint would result in the formation of dried particles of white lead dust. The presence of such dust in the atmosphere of a room is very dangerous to the health of the inmates.

Lehmann, K. B.: Giesserfieber Zinkfieber, Arch. f. Hygiene, 1910, Bd. LXXII., s. 358.
The Decorator, Nov. 22, 1913, Vol. XII, No. 138, p. 204.
"Safety and Sanitation in the Manufacture of Paints." Dr. Francis D. Patterson, Paint & Varnish Record, Dec. 1, 1913.

Fortunately the use of flatted white lead has been largely abandoned for *wall and ceiling* decoration, and its place has been taken by the more sanitary leadless Flat Wall Paints.

It is evident from a consideration of the foregoing discussion that with the adoption of preventive measures, the installation of dust-retarding apparatus and the wider use of prepared paint products, lead poisoning will be done away with almost entirely.

PART III
The Relative Toxicity of Volatile Thinners

The toxic properties of certain volatile paint thinners has been discussed in a most excellent treatise which has recently appeared under the title: "The Hygiene of the Painters' Trade." This publication was issued as Bulletin 120 of the United States Department of Labor. The author is Dr. Hamilton, whose investigations are already well known to the members of this Association. A brief digest of Dr. Hamilton's article is herewith presented:

> The painting trade is responsible for many cases of lead poisoning. The use of white lead, however, is necessary in the better type of exterior paint. For interior painting, white lead may be entirely replaced by the non-poisonous, leadless paints (lithopone and zinc paints). Any type of paint, whether made of lead, lithopone or zinc, may, if thinned with large quantities of benzine, cause sickness among painters, if such paints are used in rooms where there is no ventilation. The vapors from paint products containing benzol, wood alcohol, turpentine, etc., are very injurious, some investigators having reported fatal results attending the inhalation of such fumes. The danger from this source is apparently easier to avoid than the danger attending the use of white lead. Among the various pigments used in the manufacture of paint, corroded white lead (Dutch or Carter process) is the most poisonous on account of the greater solubility of lead carbonate in the gastric juice. Physiological experiments at the University of Chicago and practical tests at the Pullman Company shops indicate that the basic sulphate of lead (sublimed white lead) is less poisonous than basic carbonate of lead (corroded white lead). The dangers attending the use of red lead as a metal paint are becoming lessened on account of the displacement of red lead by other less poisonous pigments, such as iron oxides, chromatized pigments, etc. The rubbing, sanding or burning of old surfaces painted with white lead is the cause of much of the lead poisoning. Wet methods of sanding will, if adopted, prevent the formation of lead dust, and thus reduce the danger of lead poisoning. Painters who fail to cleanse their hands properly before eating, either on account of their ignorance of the principles of hygiene, or because of lack of time and facilities for such ablutions, are apt to become sufferers from lead poisoning. Much of the poisoning in the painters' trade will disappear when certain regulations are adopted, which will provide for more cleanly and sanitary conditions.

It is evident from Dr. Hamilton's able presentation of this subject that the thinners used in paints are in some cases quite as much to blame for the indisposition of painters, as the pigments present.

The writer has for some time studied the character and physiological effect of various volatile thinners and the results of a series of tests just finished will be presented herewith. The tests were made by subjecting Guinea pigs to the vapors of paint products, thinned with large percentages of volatile substances. The animals were separately placed in specially designed boxes and kept under observation for a long period before subjecting them to the tests. The animals were confined in the upper part of the boxes upon wire netting over a portion of which was placed perforated cardboard. Bedding, food and water were supplied, and the animals' weight recorded daily. The lower portion of the box was painted on the inside, the painted area averaging 10 sq. ft. and requiring for each coat about 6 ounces of paint. The paint used was white lead paste containing 10% of linseed oil, thinned in each instance with 40% of volatile thinner, such as turpentine, benzol, benzine and high-boiling paint petroleum spirits. One of the boxes was coated with shellac cut with wood alcohol (4 lbs. to the gallon). Another box was coated with shellac cut with denatured alcohol (4 lbs. to the gallon).

Subsequently, tests were made by exposing large open vessels containing a pint of the various thinners, in the lower part of the boxes. The experiments were made with *both* ventilated and unventilated boxes. The results of the tests are shown in the following charts:

CHART I

Experiments conducted in well ventilated boxes. Lower compartments painted with products containing 40% volatile liquids.

Pig No.	*Volatile in Paint*	Weight of Animal 1st day	Weight of Animal 3rd day	Condition of Animal at end of experiment
1	Wood Alcohol	Grams 302	Grams 312	Normal
2	Denatured Grain Alcohol	291	305	"
3	Turpentine	188	199	"
4	Benzol	278	289	"
5	Benzine 68°	230	239	"
6	High Boiling Point Petroleum Spirits*	235	240	"

* Flash Point Open Cup 102° F., Boiling Point 320° F.

CHART II

Experiments conducted in partially ventilated boxes. Lower compartments painted with products containing 40% volatile liquids.

Exp. No.	Volatile in Paint	Weight of Animal 1st day	Weight of Animal 3rd day	Condition of Animal at end of experiment
		Grams	Grams	
1	Wood Alcohol	310	308	Rather sluggish
2	Denatured Grain Alcohol	308	305	" "
3	Turpentine	200	190	" "
4	Benzol	281	252	Dead
5	Benzine	233	233	Rather sluggish
6	High Boiling Point Petroleum Spirits	240	212	Apparently normal

CHART III

Experiments conducted in partially ventilated boxes. Open pint cans of volatile liquids placed in lower compartments.

Exp. No.	Volatile	Weight 1st day	Weight 2nd day	Weight 3rd day	Weight 4th day	Condition of Animal at end of experiment
		Grams	Grams	Grams	Grams	
1	Wood Alcohol	298	300	293	288	Only slightly affected
2	Turpentine	201	200	196	197	Apparently only slightly affected
3	Benzol	254	255	250	241	Sluggish
4	Benzol containing 5% nitro-benzol	302	300	290	285	Very Sluggish
5	High Boiling Point Petroleum Spirits	241	239	242	240	Normal

It is quite apparent from these tests that the fumes of certain volatile liquids have considerable effect upon animals confined in quarters not properly ventilated. Rapid loss of weight is indicated in many instances. The liquid that was least volatile (high boiling point petroleum spirits) proved least dangerous, and this result would seem to justify the opinion of many, that these spirits are best suited as the thinners for interior wall paints.

Ordinary 68° benzine and benzol, on account of their great evaporative tendencies, proved quite dangerous. The presence of nitro-benzol is evidently harmful. It caused great discomfort, from the start of the test, to the animal subjected to its fumes.

The results of Series No. 1 are interesting, for they show that when ventilation is supplied, the vapors of different volatile compounds are not effective. Such vapors are elastic substances, and they expand rapidly throughout the air in a ventilated room, their effect being dissipated by dilution. A brief description is given herewith of the various substances used in the above described tests.

Benzol. Benzol, a very light volatile substance, obtained as a distillate from coal tar, has been found useful as a solvent and thinner for several kinds of paint products. That benzol should be used only where *ample ventilation is provided* seems evident from the many cases of benzol poisoning which have been recorded.

A prominent master painter of Pittsburgh recently called to the writer's attention the serious results attending the use of a well known paint upon the walls of a cement swimming tank. The painters, while applying the first coat, suffered from severe headache and became very dizzy. The writer's analysis of the first coater used showed that it contained a large percentage of benzol. The second coater did not contain benzol. The benzol was probably used to increase the penetrating properties of the paint. The use of benzol in such a paint, upon a tank where there was no ventilation, was probably responsible for the discomfort suffered by the painters.

Glaser[1] comments upon several cases of benzol poisoning in Baltimore, some of which were fatal. The vapor of benzol used in the canning industry as a solvent for rubber used in sealing the cans is evidently the cause of pernicious anemia.[2] Glaser thinks that the nitro-benzol present in ordinary benzol may be the active poison. If this is true, it is possible that the benzol manufacturers may be able to eliminate all traces of nitro-benzol and thus produce a benzol less poisonous in nature.

Benzol cannot very well be replaced by other thinners, for certain purposes. For instance, it is unexcelled as the thinner for exterior paints which are to be used as the primer for hard, refractory woods. In shingle stains, benzol is found most useful, as it carries the stain deeply into the shingled surface and thus provides a more enduring treatment. When thus used, upon exterior surfaces, benzol, of course, has no effect upon the painter, as its fumes are immediately diluted in the atmosphere. As a constituent of some types of asphaltic *paints*, benzol has found a wide use and cannot well be replaced by any other less poisonous thinner of equal solvent properties. It can, however, be used in some bitumastic paints, in admixture with the less poisonous and less volatile thinners.

Benzine. Benzine, the ordinary 62° distillate from petroleum, was at one time used as a substitute for turpentine in thinning paints.

[1] Report of Several Cases of Poisoning by the Vapor of Benzol. J. S. C. I., Vol. XXX, 1911 p. 49.
[2] Report of Dr. L. N. Selling. Johns Hopkins Bulletin, Feb., 1910.

When paints thus thinned were used in closed rooms, the rapidly evaporating benzine would fill the air, and cause dizziness and headache among the painters at work. An interesting example of the effect of benzine poisoning was recently brought to the writer's attention. The trimming tanks and bilge boxes of a battleship were to be painted with bitumastic paints. These paints usually contain a large percentage of Benzol. The compartments were difficult of access, and without ventilation except for a quantity of air that was pumped in by portable blowers. During the application of the paint, the compartment became filled with vapors which made the painters very ill. They showed signs of burns upon their skin, which appeared like the burns caused by the vapors of carbolic acid. Some of the men had to stay away from work several days before recovering from the effects referred to. One of the officers of the ship went into one of the compartments during the painting, and had difficulty in returning. He became weak and dizzy and subsequently suffered from a severe headache for some time. Experiments have been made to overcome such conditions, by supplying the painters with air helmets. Such equipment is, however, unhandy, unwieldy and expensive. The use of bitumastic paints, compounded with oils and reduced only with very high boiling point petroleum thinners,[5] has since eliminated the danger from such work.

The great rapidity of evaporation of ordinary light benzine when used in paints often results in the formation of pinholing, lapping, and other surface defects of an unsatisfactory nature. These conditions brought about the introduction of petroleum distillates having high flash and boiling points, similar to turpentine. These high-boiling point petroleum distillates have almost entirely replaced benzine and turpentine as the thinners for wall paints.

The use of high boiling petroleum thinners of this type, if properly refined, has probably never caused any discomfort to painters, especially in ventilated chambers. Through the introduction of prepared paints thinned with high-boiling point spirits, the danger which once attended "flatting work" through the use of paste paints washed with turpentine, has almost entirely disappeared.

[illegible]. Previous to the development of denatured grain alcohol, wood alcohol was used in great quantities as the cutter for shellac, the high solvent properties of the wood alcohol making it very suitable for this purpose. The rapid drying of shellac varnishes to a tough, water-resistant film, developed for them many applications in the commercial world. For painting, varnishing or lacquering ships' bottoms, brew vats, floors, wooden trim, confectionery, leather, toys, etc., these products have become very useful. The fumes of wood alcohol, however, which come from the drying of shellac varnishes, may possibly be dangerous to workmen when they are confined in closed rooms or in large, unventilated vats or tanks. For this and for economical reasons, denatured grain alcohol has largely replaced wood alcohol in the varnish trade.

[5] [illegible] U. S. Patent

In a report pertaining to the chemistry, technology and pharmacology of wood alcohol, Charles Baskerville[6] refers to the following reported cases of poisoning from the use of this substance:

> "*Case No. 5* (193). A painter, age 39, used wood alcohol to wash varnish from hands every day after work.
> "Result: Became totally blind and has remained blind.
> "*Case No. 6* (191). A distributor of paints and alcohol in storeroom of paint factory, age 53, spilled a quart of wood alcohol on his feet and floor, and remained in same room for some hours.
> "Result: Became totally blind.
> "*Case No. 7* (195). A photographer, age 32, cleaned plates with wood alcohol.
> "Result: Was seized with paralysis of arms and legs, pain in sides and decrease in sight. Died after some time."

Although the cases referred to above show that wood alcohol must be handled with care, it is probable that many statements have been made regarding the poisonous nature of wood alcohol, which are not founded on absolute fact. In a recently issued pamphlet,[7] the wood alcohol manufacturers present communications from large industrial concerns that are extensive users of wood alcohol. The writers of these communications apparently regard wood alcohol as non-poisonous, especially when used in ventilated rooms.

In striking contrast to this opinion, may be cited the testimony presented at the hearing held before the Ways and Means Committee of the Fifty-Ninth Congress, which shows that wood alcohol has proved highly poisonous when used in the hatters' trade as a solvent for shellac. It is probable that its constant use for long periods of time was responsible for many of the cases cited. While Baskerville points out that the danger from wood alcohol poisoning is largely eliminated when the fumes are diluted with a sufficient quantity of air, it is apparent that this precaution may not always be taken and that under such conditions, grain alcohol would be the preferable solvent for shellac.

The following quotation from page 961 of Baskerville's article will be of special interest to master painters:

> "Local Union 111, of the Brotherhood of Painters, Decorators and Paperhangers of America, in 1905, voted that the use of wood alcohol in paints, shellac, and varnish be prohibited, and the members were warned against the use of it."

The writer's experiments have indicated that wood alcohol is only an internal poison. Blindness and fatal results would probably attend the drinking of an ounce of wood alcohol. It would, however, probably be necessary for the system to actually absorb over an extended period, an amount of wood alcohol vapor equal to an ounce of the liquid, to produce like results. This could hardly occur in a well ventilated room.

[6] Wood Alcohol. Chas. Baskerville. Appendix V to 2nd Report of N. Y. State Factory Investigating Commission.

[7] The Truth About Wood Alcohol. Wood Products Co., Buffalo, N. Y., Nov. 10, 1913.

Special No. 1 Denatured Alcohol is the grade now used to some extent in place of wood alcohol as a solvent in the manufacture of shellac varnish. This special alcohol is made by mixing 100 parts by volume of grain alcohol, with 5 parts by volume of approved wood alcohol.

Turpentine. In a previous article[1] the writer has shown that turpentine vapors are rather dangerous when inhaled in quantity. The effect of such vapors upon the kidneys has been pointed out by Shoemaker and other medical authorities.[2,3] However, it is a matter of common knowledge that turpentine must be used as a thinner for certain types of varnishes and enamels, where a thinner of high solvent powers and slow evaporative value is required. When such products are used, therefore, it is necessary that the painter should provide ample ventilation to the room in which he works.

Summary of Conclusions

Lead poisoning may occur through the inhalation of the dust from dry lead pigments, or by the careless handling and hand-mixing of lead paints. It may be prevented by establishing more cleanly and sanitary working conditions, through observance of the rules of personal hygiene and by the adoption and use of prepaired paint products.

Drying oil paints do not evolve metallic vapors. They do, however, give forth small quantities of carbon monoxide gas. Paints also emit in vaporous form the volatile products used as thinners. Of these products, benzol is most dangerous, while high-boiling point petroleum spirits is least harmful. With proper ventilation, the fumes from drying paints are diluted and dissipated by the atmosphere so that they become harmless.

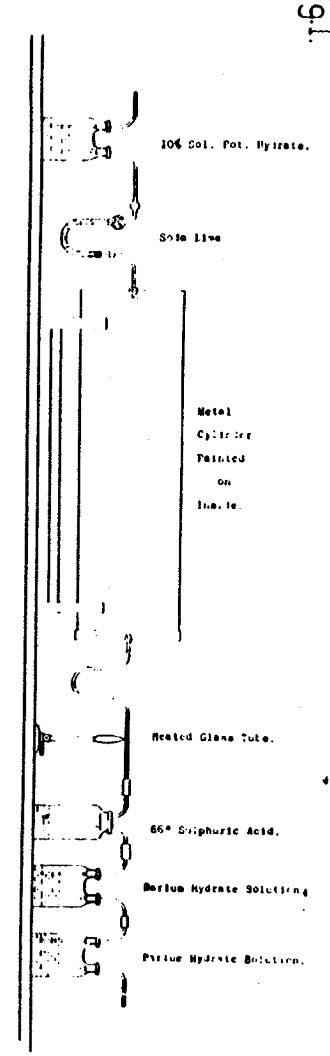
Drying oil paints evolve aldehydes and other germicidal substances in vaporous form. The antiseptic effect of such vapors is pronounced. The application of oil paints is therefore to be considered as one of the most efficient means of rendering living and sleeping rooms thoroughly sanitary.

[1] Paint Vapors and Their Physiological Effect upon Painters. H. A. Gardner. Presented before the M. H. P. & D. A. of A., Denver, Col., February, 1915.

[2] Materia Medica and Therapeutics. J. V. Shoemaker, p. 807.

[3] Peterson & Haines. Textbook of Legal Medicine & Toxicology, p. 589.

Fig. I.



Apparatus for Determining Character of Vapors From Painted Surface.

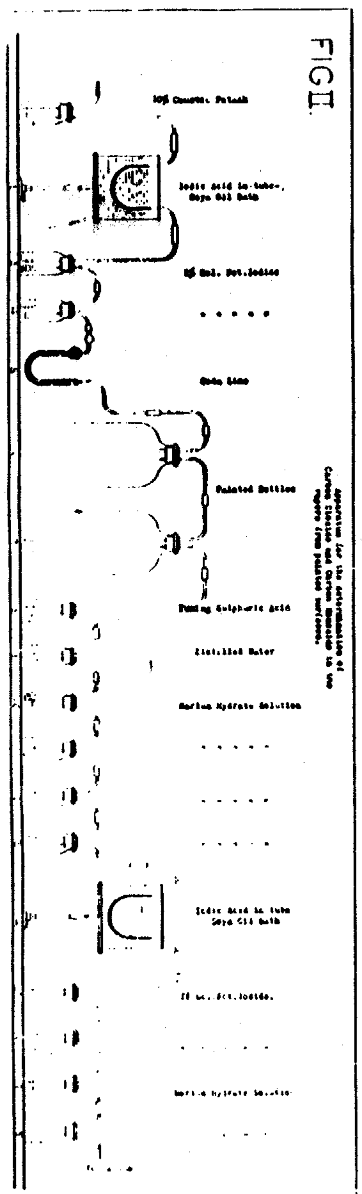


FIGURE 3 PAINTED BOX FOR DETERM
OF PAINT VOLATILES UPON

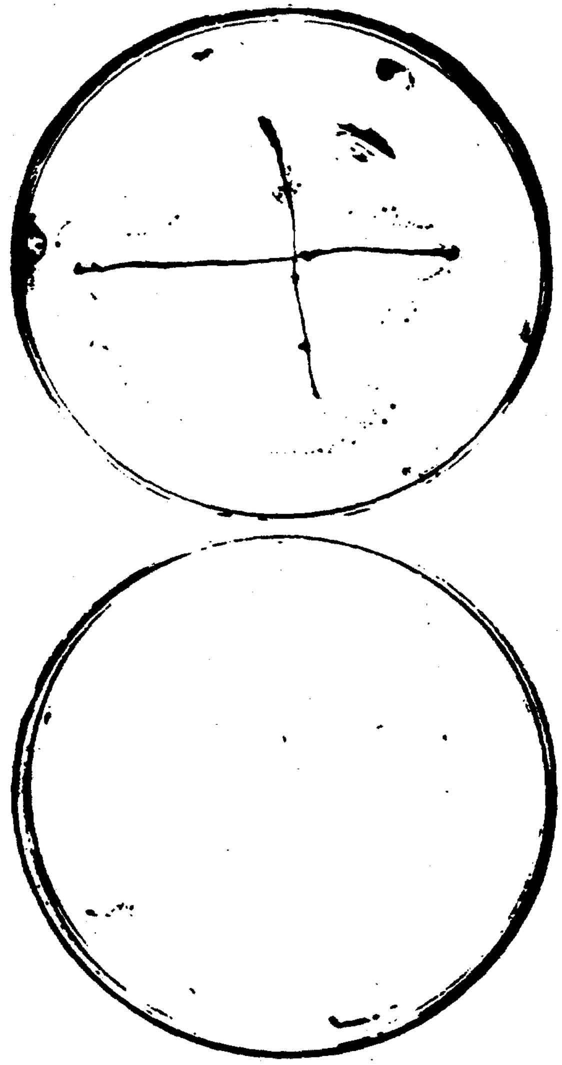


FIGURE 4—SHOWING ANTISEPTIC PROPERTIES OF OIL PAINT VAPORS NOTE GROWTH OF BACILLI ON AGAR PLATE AT TOP. NOTE ABSENCE OF BACILLI ON AGAR PLATE AT BOTTOM—SEE TEXT