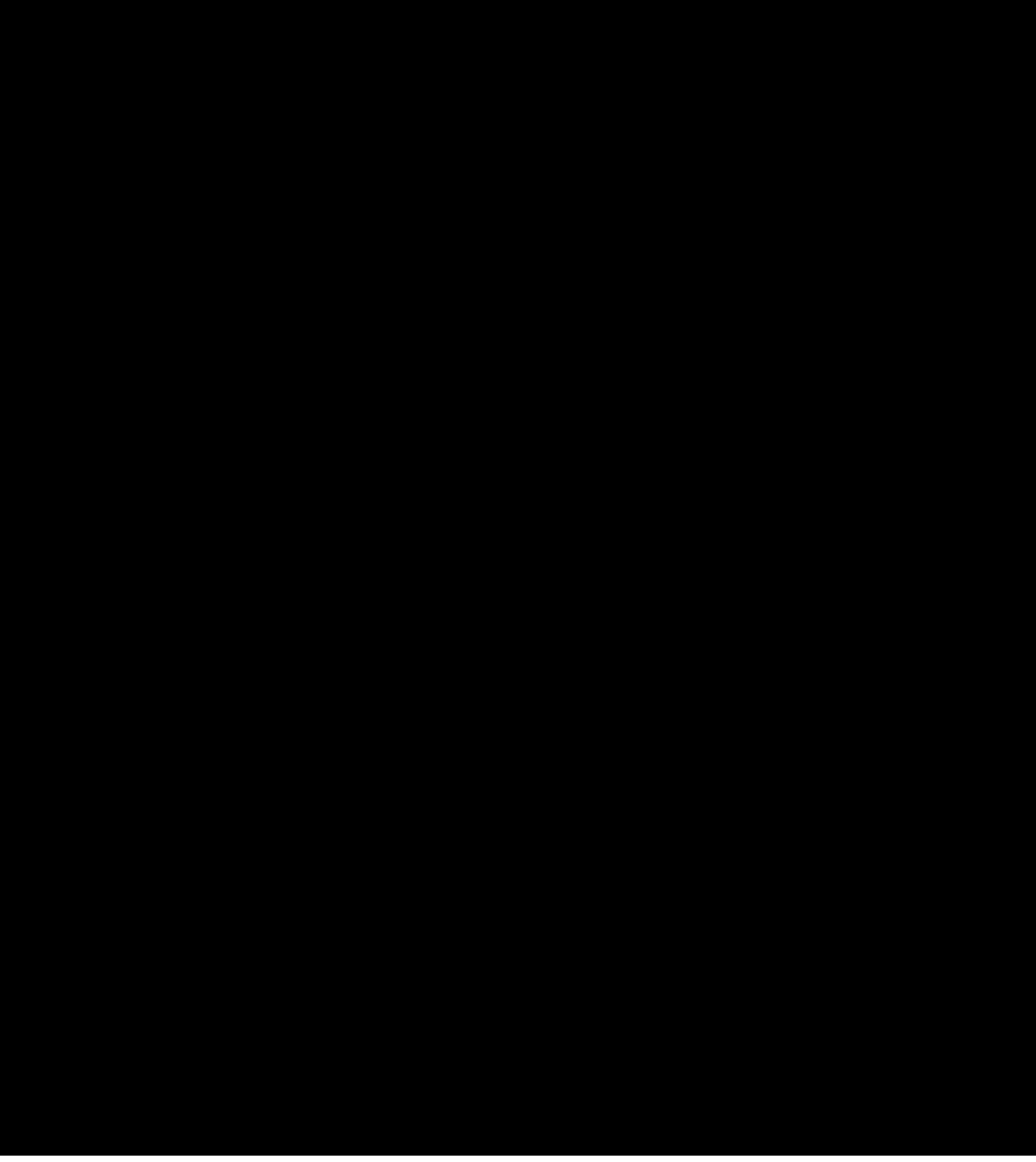




AN

INDUSTRIAL HYGIENE SURVEY
OF THE KENSINGTON PLANT
OF THE SHERWIN WILLIAMS COMPANY

0007-SWP-000030430

AN
INDUSTRIAL HYGIENE SURVEY
OF THE KENSINGTON PLANT
OF THE SHERWIN WILLIAMS COMPANY

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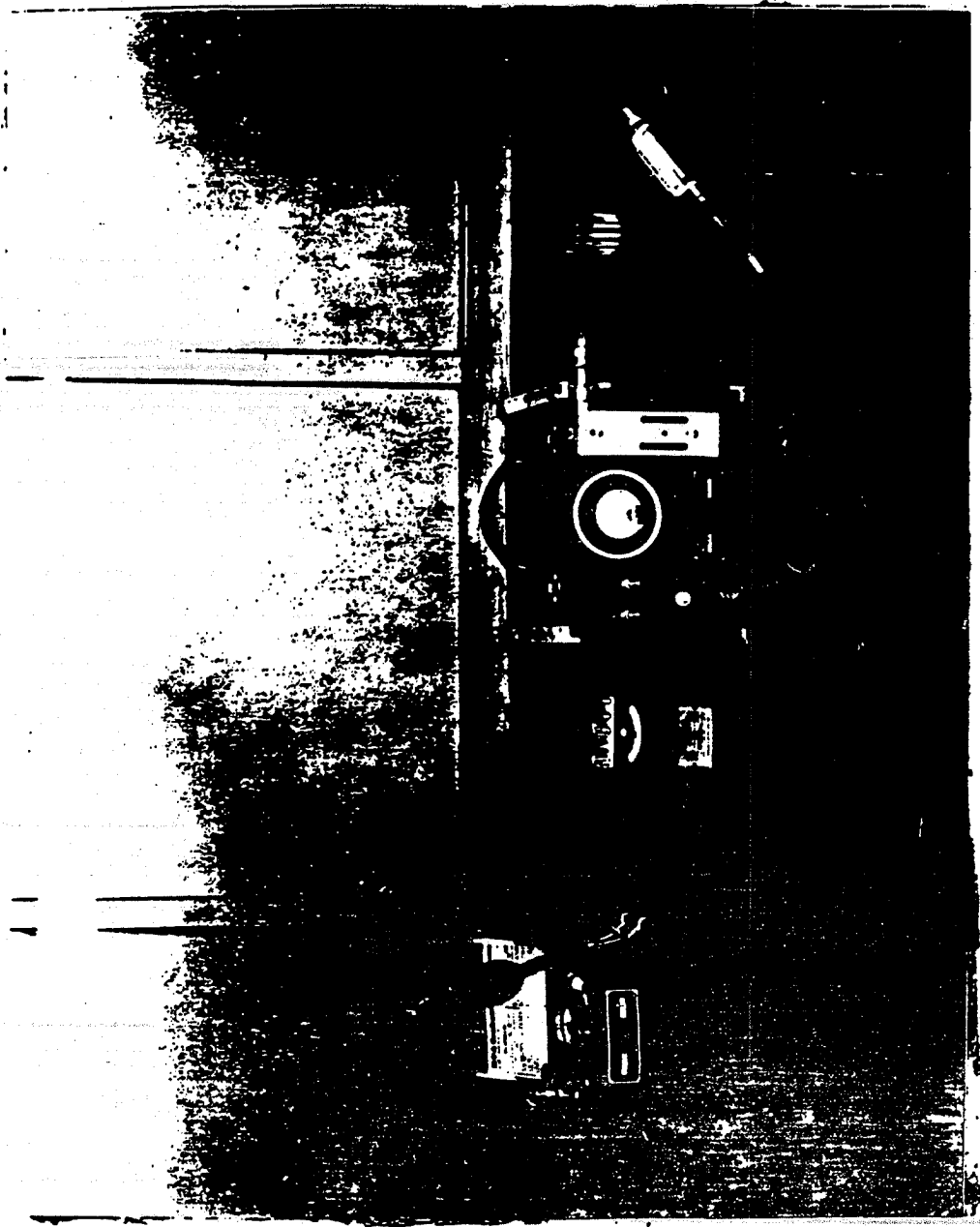
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Period of Investigation—September 2, 1937 to November 15, 1937

REPORT PREPARED BY THE INDUSTRIAL HEALTH CONSERVANCY LABORATORIES

10 Peterboro, Detroit, Michigan



Typical Equipment Used in Industrial Hygiene
Investigation Work. Inflammable Vapor Detec-
tor, Carbon Monoxide Detector, Hydrogen Sulfide
Detector

THIS IS VOLUME III OF A THREE VOLUME REPORT

0007-SWP-000030433

THIS IS A CONFIDENTIAL REPORT

0007-SWP-000030434

**POTENTIAL AND PRACTICAL EXPOSURES FROM RAW MATERIALS USED
IN THE LACQUER DEPARTMENT**

One single department has been selected for brief running comment on practically all the raw materials utilized. Within certain limitations, the majority of all of these substances are applied to some extent in all other of the chief manufacturing departments. Therefore, to avoid endless repetition, no attempt has been made to discuss these same raw materials as manipulated in these other departments. It is obvious that the same materials are everywhere harmful in proportion to the extent of use and in proportion to the presence of objectionable work conditions attending their use. This presented material now follows through several pages.

LACQUER DEPARTMENT

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
3	Silica	Silica is the most dangerous of fibrogenetic dusts, but danger is limited to the inhalation of very fine particles (below 10 microns in size) in high concentration (roughly above 5 million particles per cubic foot of air) and over long periods of time such as for 3 years. Single exposures to clouds of silica dust such as for 1 day are quite unimportant. Long continued exposure leads to a direful disease, silicosis, which is incurable and which is frequently associated with tuberculosis. See additional comment in special sections such as Dust Counts.
8	Tuscan Clay	This substance and most other silicates (asbestos chief exception) are comparatively harmless. Dangerous in proportion to content of free silica which ordinarily is below 8%. No less, claims are being made in many industries for alleged dusty lung diseases following exposure to silicates. Claims are made for alleged diseases termed "silicosis." Inorganic silicates are approximately only 3% as harmful as silica. No less, the legal situation may become troublesome.
15	China Clay	See preceding item.
19	French Ochre	Iron oxides in all colors have proved to be among the least dangerous of all dusts following inhalation. Associated with free silica dust, iron oxides probably serve a beneficent purpose and may prevent the occurrence of silicosis and even may tend to retard the progress of an existing silicosis. Some French ochres have an appreciable content of lead as an impurity. The small lead content may be more significant in terms of toxic properties than iron oxides themselves.
20	Asbestine Pulp	Asbestos and similar bodies represent variable but always complex silicates, chiefly magnesium silicates. This silicate is one of the few exceptions to the established fact that silicate dusts are harmless. Magnesium silicate dust, under conditions of adequate exposure, may lead to a definite dusty lung disease best known as "asbestosis." This disease is dissimilar to silicosis, presents different x-ray characteristics and is less likely to be associated with tuberculosis.
20L	Talc #482	Most talcs are complex magnesium silicates, and as such, under conditions of extensive exposure, may lead to asbestosis. This substance is chiefly harmful in proportion to the amount of free silica or magnesium silicate present.
21	M S Raw Turkey Umber	This substance is harmful in proportion to its content of manganese dioxide and free silica. Manganese dioxide may be present to an extent of as high as 17%. This is quite sufficient to induce manganese poisoning if great dustiness

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
		(Cont'd)
21	M S Raw Turkey Umber	is provided and if inhalation takes place by workmen. Content of free silica is ordinarily too low to be significant.
22	Burnt Turkey Umber	See Item # 21.
25	W L Raw Italian Sienna	See Item # 21 above.
26	P P Burnt Italian Sienna	See Item # 21 above.
27	# 1371 Van Dyke Brown	Chiefly organic material. No more toxic than coal dust, that is, practically harmless.
32	EB Cosmic Black	As here used, essentially harmless. Possible source of low grade skin disease through sensitization.
101	High Tone Carbon Black	This comment is intended to cover all carbon blacks. Some may contain oil as an impurity and occasionally a free silica content may be detected. Primarily, this substance is innocuous.
257	Zinc Dust	On the assumption that this is metallic zinc powder, this substance is rated as substantially harmless.
292	Aluminum Bronze	Although a disease has been termed "aluminosis" this is probably unwarranted. Metallic aluminum dust is essentially harmless. In fact, when associated with silica it may tend to prevent the occurrence of silicosis.
306	CP Barytes	This salt of barium is much used in medicine. Some other salts of barium are distinctly harmful, such as the carbonate and chloride. The manipulation of crude barium such as in the manufacture of lithopone may be associated with dangers from impurities.
316	Oxalic Acid	Highly dangerous acid. Unimportant as used because of trivial amounts involved.
402	Mahogany Oil	Skin irritant.
405	Nigrosin	Skin irritant.
440	Magnesium Carbonate	Almost entirely harmless. Used in medicine.
461	Albalith	Lithopone. The making of lithopone may be associated with divers exposures. See special section. Lithopone as here used, and as generally used, is rated as almost entire- ly innocuous.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
478	Chrome Oxides	Chromic acid, chromates and various compounds of chrome are toxic, but not all are toxic. Certain valences of chromium yield harmless compounds. Typical action of chromium as produced by chromates are "chrome holes" and by nasal septal perforations. Chief action is local, but bronchitis may be produced. Sensitization followed by systemic disease is possible. In general, chromium compounds are distinctly injurious.
488	1450 Graphite	Fundamentally harmless, but may be troublesome because of free silica content. Rarely produces skin disease.
547	Aluminum Stearate	Occasional source of skin disease.
566	Whiting	This is calcium carbonate and therefore essentially harmless.
597	Vac Dry White Shellac	If this represents bleached yellow shellac and is not buckwheat shellac, may contain arsenic as an impurity and may be potentially dangerous. Shellac is a known skin irritant but is chiefly important because of solvents in which it may be dissolved.
630	Ester Gum	Low grade skin irritant and sensitizer.
637	W W Rosin	Low grade skin irritant.
1087	Gilsonite	Low grade skin irritant.
1097	Titanox B	Titanox dioxide is a very inert substance. Recent reports describing "titanosis" as a dusty lung disease probably not warranted. Here rated as innocuous.
1112	Spirit Copal Gum	Skin irritant and sensitizer.
1117A	XXX Antimony Oxide	Antimony is a dangerous substance, particularly when inhaled as dust. It is more toxic than lead. Chief manifestations related to gastro intestinal tract.
1128	SB Fumed Litharge	One of a great variety of lead compounds manipulated in this plant. These lead compounds constitute the most practical of all exposures. All lead compounds are toxic, particularly when taken into the body through inhalation. Ingested lead harmful in proportion to solubility. See special section devoted to lead poisoning.
1132	Hapico Yellow Lemon	See Item # 19
1206	Slate Flour	Mixture of free silica and silicate with other minerals. Content of free silica as high as 27%. Because of this fairly high content of free silica a possible source of dusty lung diseases.
1219	Pelenite	See Item # 8

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
1224	Manilla Gum	Skin irritant and sensitizer.
1225	(1286) Residue	Skin irritant and sensitizer.
1226	Nitrocellulose	In the absence of burning nitrocelluloses are harmless but as manipulated may be wetted with denatured alcohol in which there may be a content of 5% wood alcohol. Dangerous material because of fires, possible explosion and wetting agents.
1237	Amberol	Skin irritant and sensitizer.
1246	Soapstone	Mixture of complex silicates with some free silica. Harmful in proportion to free silica content and extent of exposure.
1267	Batu Indian Rubs	Natural resin which may constitute skin irritant and sensitizer.
1400	Chinese Blue	100% ferric ferrocyanide. Harmless unless highly heated. Dangerous in the presence of fire.
1401	Ultra Blue	Silicates with some sulphur compound. See Item # 8.
1409	Zinc Stearate	Widely used as a baby powder although a few persons acquire skin disease from its action.
1412	Roman Gold	Finely powdered brass. Workers handling this substance may present greenish skin and even greenish hair. Relatively unimportant.
1414	Rottenstone	Mixed silicates. See Item # 8.
1415	Black Kadax Zinc	Zinc oxide. Practically inert, but in the manufacture thereof, low grade skin diseases have been described, also zinc chills.
1418	Rezyl 12	Alkyl type of resin. Possible skin irritant and sensitizer.
1440	Synthetic Resin	Many synthetic resins are potentially skin irritants and sensitizers.
1441	Bentonite	Colloidal silicates with some content of free silica. Lately has been reported as source of a dusty lung disease.
1442	Gum Tragacanth	Although much used in medicine, has produced skin disease on account of sensitization.
1443	Eg-Glo	On the assumption that this is a zinc tung oil compound, this substance may produce skin disease.
1444	Neomerpin	Many industrial soaps produce skin irritation or skin sensitization.
1448	White Star Timonox	See #1117A
1509	Snow Floss	In Acme Plant, this item is reported as zinc stearate. Here reported as free silica. If latter, see item #8. If former, see #1409.
1573	Beckacite Gum	Alkyd resin—see #1418.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
1536	Aracelor	Chlorinated synthetic resin. This general type of chlorinated waxes or resins, newly introduced, is proving to be highly dangerous. If this substance and others similar resemble "halowaxes", their use should be discouraged or at least carefully supervised until the extent of danger is fully established.
1538	Zinc Sulphide	This substance is essentially harmless. See #461.
1552	Hi-Flow Super Cel	Believed to be very fine free silica. See item #3.
1721	Permanent Green	Chromium Oxide. See #478.
1762	Cadmium Red, Lt.	This cadmium selenium sulphide is believed to be highly toxic and possibly ten times as toxic as lead. 1 mgm. inhaled in the form of dust per day may be regarded with apprehension. Chiefly important because of cadmium content, although selenium itself may be harmful.
1900	Siegle Blue	See #1400.
1904	Smoked Rubber	May be a skin irritant if any rubber accelerator present.
10109	Para Toner	Possible skin irritant.
10189	Toluidine	Raw materials and intermediates believed to be highly toxic. May produce acute nephritis, cyanosis, dizziness, bladder disturbances, bloody urine, damage to the blood.
10612	Orange Pulp	Lead Chromate in oil. See item #1128.
10641	Chrome Yellow Pulp	In addition to probably containing lead chromates, contains xylol, which is toxic. Xylol is a homologue of benzol and is less toxic only because of less evaporability.
10643	Orange Pulp	See #10642.
10680 through D 2136		In this department, a great variety of chrome green, yellow, orange, lemon, etc., is used, along with various types of blues, reds, etc. Nearly all of these substances contain lead or chromium, but are better discussed in connection with other department operation where such substances are made. The practical danger is much less in the Lacquer Department than in connection with the manufacture of these substances.
On 165	Celite	Mixed silicates with some content of free silica. Harmful in proportion to content of free silica.
?	Methyl Amyl Ketone	This class of substance lately has attracted attention as toxic, leading to a condition somewhat resembling wood alcohol poisoning.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
CY 2614	Wood Filler	Contains silica and asbestos. See items #3 and #20.
CB 130 through a variety of CB numbers, B numbers, BX numbers, CP numbers.		A great number of theoretically harmful substances which are better discussed for other departments. In Lacquer Department, relatively unimportant.
CP 456	Methyl Violet Ink	This particular dye is particularly irritating to eyes, leading to corneal ulceration. More important than ordinary inks or dyes.
CP 480	Naphthalene	Minor irritant to eyes and respiratory tract tissues.
CW 695	Golden Cadmolith	See item #1762.
CW 749	Air Floated Rose Tripoli	This substance is not mixed silicates, as stated in the Raw Material Section, but instead is approximately 99% crypto-crystalline free silica. The electrostatic properties of this substance prevent highly dusty workrooms. Real danger to silicosis in proportion to dustiness and extent of exposures.
CW 753	XR 3180	Bakelite resins are highly conducive to skin diseases from formaldehyde content.
CW 970	Cellulose Acetate	This substance is even less harmful than cellulose nitrate. Combustion products less harmful. Important chiefly because of materials in which may be dissolved.
CW 373	Vinsol	This turpene resin is possible source of low grade skin irritation.
CW 394	Orange Cadmolith	See #1762.
(2)	Raw Linseed Oil	Occasionally leads to minor skin disease. In connection with storage in enclosed areas and when coated on surfaces may give off carbon dioxide or other asphyxiant. Tank cars and other tanks lately empties of this oil should not be entered without due caution and protection.
(13)	Boiled Linseed Oil	See (2).
(14)	Steam Distilled Turpentine	Earlier the steam distilled turpentine was a definite skin irritant and more so than any other known turpentine. Improved industrial processes for manufacture apparently have eliminated some irritant properties of steam distilled turpentine, but it is still regarded as a definite skin irritant. Given any choice, a preference should be exercised for gum spirits turpentine.
(30)	Solox	If denatured with wood alcohol, this fact is important, because of possibility of wood alcohol poisoning. As here used, unimportant because of low quantity.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
(88)	WMP Naphtha	Naphtha, like all light petroleum derivatives may produce acute or chronic systemic disease or localized skin disease. Acute intoxication common. Commonly termed "naphtha jag". Chronic form rare and resembles multiple sclerosis. Associated with damage to liver and kidneys. For elaborate discussion see Hayhurst's article, "Industrial Medicine", 1935 or 1936.
(140)	China Wood Oil	This widely used oil has long been regarded as not more harmful than as a minor skin irritant. Lately considerable interest has been attracted to this substance as having greater toxic properties and is said to cause violent purging, skin ulceration, etc. These statements possibly are exaggerated or may apply to only one or two species of trees giving rise to this oil.
(141)	SW Kerosene	See (53).
(149)	90% Benzol	At the present time, the consumption of benzol in paint manufacture is practically nil compared with the period ten or fifteen years ago. The reason for this diminution in use is primarily the well known dangers to users of benzol coatings and to a lesser extent the manufacture of such articles. The toxicologic literature of this country is replete with articles on benzol poisoning. The present investigators have written a small book presenting the outstanding features of benzol poisoning and the conditions under which it may arise. This coal tar hydrocarbon, when present in such concentrations as 100 parts per million of air may in time cause chronic poisoning. Such a concentration as 1000 parts per million almost inevitably will affect the majority of workers long exposed. A very high concentration will lead to acute benzol poisoning which is entirely different to the better known chronic form. In the acute variety, the outstanding manifestation is narcotism, with death occurring in a few hours or a few minutes. In the chronic variety, the chief point of action is upon the cells of the blood leading to marked diminution in both white and red cell counts. The ensuing condition is described as aplastic anemia. It is the intent of this extended comment to discourage the use of benzol and to urge full protective apparatus and procedure connected with its every use in this plant.
(152)	Cobalt Drier	Various cobalts, lead manganese driers, are theoretically rather than practically harmful. Also these substances are used in comparatively low quantities. No less, all these metalliferous driers should be respected. See (4092).

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
(187)	Methyl Acetone	Until recently acetone has been regarded only as a skin hazard. Recent work tends to attach some significance as a source of systemic disease. See the Journal of Industrial Hygiene, Vol. 18, February, 1956, "The Relative Toxicity of Acetone, Methyl Alcohol and their Mixtures".
(188)	Elaine Red Oil	Oleic acid in crude form is a definite skin irritant. When pure, less so.
(241)	Toluol	This widely used solvent is a homologue of benzol, and possesses toxic properties of very similar nature. It is less toxic only because its boiling point is higher. The clinical picture produced through the action of toluol is identical or at least very similar to that for benzol.
(293)	White Steam Distilled Pine Oil	This distillation product connected with turpentine manufacture has both been a source of skin disease and recommended treatment for skin disease. It has proved useful in the treatment of athlete's foot and other ring worm infections. As here used, is fairly unimportant.
(330)	Ethyl Alcohol	Ethyl alcohol, much used for beverage purposes, may become an industrial intoxicant if long exposures are provided to high concentrations of vapors or if long sustained skin contact is provided. In such operations as the making of nitrocellulose chips, enough ethyl alcohol may be present in the air to impair the normal mental functioning of workmen by producing ordinary drunkenness. Of greater importance is the 5% wood alcohol used for denaturing purposes. Even this low percentage of methanol may lead to ill consequences, particularly when associated with the effects of the ethyl alcohol.
(348)	Oleum Spirits	See (63).
(392)	Oil Drier	Of minor importance as a skin irritant and sensitizer.
(423)	Blown Soya Bean Oil	Possible source of skin disease.
(429)	Grinding Varnish	Such substances may contain a variety of solvents, including naphtha, toluol, etc. See items (241) and (63).
(434)	CP Glycerine	Concentrated glycerine (above 30%) may produce skin disease.
(438)	Paraffin Oil	Paraffin oil, although freely used in medicine, must be recognized as having low grade neoplastic properties. Paraffinomas are well known following the introduction of solid paraffin in pseudo-cosmetic surgery. Continuous contact with paraffin oil is therefore undesirable.
(534)	Xylol	This solvent is a higher homologue of benzol and along with toluol has been much substituted for benzol. Having a higher boiling point, its vapors do not readily arise in connection with its use. It is a preferred substitute on this account for benzol.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
(690)	Sulphuric Acid	Usual exposures associated with mineral acids, for the most part accidental. Sulphuric acid, however, does not evaporate readily.
(864)	Formaldehyde	Properly speaking, formaldehyde is a gas and the liquid equivalent is formalin, which is a 40% solution of formaldehyde in water. Formaldehyde or formalin is a profound irritant to skin, eyes, respiratory tissues, and is capable of damage to liver and kidneys. This substance has such definite warning properties that it is seldom improperly used.
(1157)	Butanol	In low concentrations, beginning at 100 parts per million, may produce nephritis and even pulmonary hemorrhage, degeneration of the liver, etc.
(1133)	Ethyl Acetate	Ethyl acetate is a low grade irritant to the skin, eyes and respiratory tract.
(1170)	Butyl Acetate	More of an irritant than ethyl acetate, but is regarded as less injurious than synthetic amyl acetate, which, in turn, is believed to be more objectionable than the natural product.
(1257)	Hi-Flash Naphtha	See (63)
(1620)	Dibutyl Phthalate	Little information available. As observed in other industries by these investigators, quite innocuous. Does not evaporate readily.
(1621)	Chronitex Tricresyl Phosphate	This substance is the source of the famous "jake paralysis", epidemic during the prohibition era. It is therefore an outstanding toxic agent when taken internally. It is not known that any industrial cases have arisen or that they may arise in ordinary pursuits. No less, it should be manipulated with caution.
(1656)	Cellosolve	Probably ethylene glycol (monoethyl ether). Toxic properties are of low order unless concentrations are very high. Publications of the United States Public Health Service available on this topic.
(1632)	Butyl Cellosolve	Slightly more toxic than ethyl cellosolve which is reported by the Federal Government as possessing only limited toxicity. Chiefly a respiratory tract irritant.
(1636)	L.D. Naphtha	See (63).
(1687)	Grinding Base	See (1621)
(1767)	Anti-Shining Agent.	Guaiacol. Used medically in cough syrups. Industrial intoxication not known.
(1826)	Acetone	The Bureau of Mines, experimenting with animals, reports an acute narcotic effect, stronger than that of chloroform and death at 110 mgms. per liter of air. Industrial poisoning little known but possible.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
(2048)	Butyl Lactate	Low grade respiratory tract irritant.
(2049)	Terpentine	Fraction from wood distillation constituent of turpentine. Chiefly skin irritant resembling turpentine in its action.
(2602)	Methyl Cellosolve	See (1682). Methyl cellosolve probably more injurious than either ethyl or butyl cellosolve.
(2611)	Isopropyl Acetate	Same order of toxicity as ethyl acetate, which is known to produce low grade respiratory irritation, nausea and rarely headache.
(2617)	Methanol	Wood alcohol. This extensive use of wood alcohol is to be associated with outstanding potential injury. Methyl alcohol is one of the most dangerous substances used in industry. Is dangerous when absorbed through the skin, breathed as a vapor or introduced orally. Produces injury particularly to the optic nerve, leading to permanent blindness, liver damage and nephritis. Should be used in industry only when not replaceable by other substances and then only under well guarded conditions.
(2624)	Methyl Amyl Acetate	Approximately the same extent of toxicity as amyl acetate, but probably slightly increased.
(2625)	Secondary Amyl Acetate	The synthetic variety is more active toxicologically than its natural counterpart. Both varieties lead to irritation of the eyes, mucous membranes, respiratory tract and occasionally the skin. Comparatively harmless.
(2638)	Shingle Stain Oil	This a coal tar solvent, probably containing higher homologues of benzol and is known to have caused severe skin disease.
(2639)	Methyl Ethyl Ketone	Action akin to acetone or methyl acetone. Probably more injurious than earlier recognized. See Journal of Industrial Hygiene, 1936 or 1937 for extensive discussion.
(2650)	Diacetone Alcohol	Approximately the same toxicity as methyl ethyl ketone.
(3028)	Apco Thinner	See (63)
(4021)	Solvesso	See (65)
(4097)	Soligen Drier	Various soligen driers contain lead, manganese, cobalt or other metallic constituents. Scarcely harmful because of liquid state.
(CW 230)	Hexalin	Is used in conjunction with various soaps to form solutions and emulsions for cleaning type. May be used in conjunction with dangerous hydrocarbon solvents. If also hexalin is a trade name for a substance akin to tetralin, tetralin is a trade name for tetrahydronaphthalene, is a turpentine substitute. Is a skin irritant. Leads to irritation of throat, headache, mental confusion, green urine.

<u>Code No.</u>	<u>Name</u>	<u>Appraisal of Toxic Properties</u>
(V 11029)	Bakelite China Wood Oil Varnish	One of a series of varnishes containing bakelite all of which are well known skin irritants.

All of the foregoing comment falls far short of ear-marking the sources of substances used in connection with lacquer, which are known to be injurious if used under improper conditions. The intent of the limited material here presented is to portray lacquer manufacturing as a dangerous trade, calling for intelligent supervision on the part of the management.

Many of the substances appearing on the Lacquer list of Raw Materials are discussed in connection with other departments, making even greater use of such substances.

POTENTIAL EXPOSURES ASSOCIATED WITH RAW MATERIALS
(A DISCUSSION OF 50 OUTSTANDING ITEMS)

In Volume II there has been presented a listing of all known raw materials entering into the operation of this plant by departments. These lists of raw materials have been furnished by the various superintendents in charge of departmental or sub-plant operations. Associated with these long lists are figures furnishing approximate consumption for one recent year and limited data as to the chemical composition of each raw material item.

In the section just preceding, there has been presented some highly condensed comment relative to the toxic properties on numerous of these raw materials such as are used in the Lacquer Department. It is believed to be undesirable here to record by departments the injurious properties of these same substances which are more or less shared by all departments.

In this present section, from the entire list of raw materials, fifty items have been selected, embracing outstandingly toxic materials very extensively used. Each one of these fifty items have been made the object of enlarged but still limited comment with reference to the nature of the diseases produced, together with a limited appraisal as to the probability of these occupational affections arising in this plant.

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The following discussions are with reference to fifty substances or groups of substances regarded as of outstanding importance with regard to industrial hygiene in this plant. These discussions are far from comprehensive and are intended only as leads or flags. In all instances, much more extensive information is available should the need arise. Also, in some instances, special sections of this report supply extended presentations.

1. Silica

Silica is silicon dioxide. It is found in many forms, but in this plant quartz, tripoli and amorphous silica are of chief interest. Exposure to the dust of silica under suitable circumstances later set forth may lead to silicosis, a dusty lung disease having specific characteristics, chiefly demonstrable through x-ray examination or at autopsy. Only silica may produce silicosis. There is no such disease as silicosis from such dusts as iron, coke, coal, titanium, lead, zinc, etc. In order that this disease may be produced, exposure is necessary to particles ten microns or less in size. A micron is $1/25,000$ of an inch. Exposures must be provided over an extended period of time, such as several years. The average years of exposure are above seven. Intermittent work, such as the handling of silica for a few minutes each day is ordinarily unimportant.

Certain dusts associated with silica apparently retard the action of silica in producing silicosis. Among other associated dusts having a helpful action are iron, aluminum, gypsum, some clays, possibly alkalis. When this disease is once inaugurated, no repair takes place, cures are impossible. The disease is progressive even in the absence of further exposures. At times the disease may not appear until long after exposure to silica is provided.

Protection against silicosis may be obtained along the following lines: a) the wearing of respirators, b) introduction of exhaust systems, c) substitution of other materials for silica, d) manipulating silica under wet conditions.

Some persons are more susceptible than others to the action of silica. This difference of susceptibility is related to frequency and depth of breathing, shapes of nostrils, presence of vibrissae, etc. Long hours of work in silica dusty areas are highly conducive to silicosis, since a ten hour day would lead to approximately double the quantity of silica inhaled in a seven hour working day. Silicosis may be diagnosed only by x-ray examination or at autopsy. The chief objective symptom of silicosis is shortness of breath, the chief objective sign diminished chest expansion. This disease may exist in a well established form in the absence of all symptoms and signs. Silicotics frequently take on increased weight in the absence of tuberculosis. Tuberculosis very frequently follows silicosis and an inactive tuberculosis may be stirred up by silicosis.

In this plant, free silica is used to a limited extent in the following departments: Dry Color, Paint and Varnish and Lacquer.

X-ray examinations have been made of a few workers handling silica in this plant. None have shown the least signs of silicosis. It is believed that silicosis will never arise in this plant under work conditions now existing.

2. Asbestos

Asbestos (asbestine, talc) is a complex magnesium silicate of varying constituency. Unlike most silicates, the magnesium silicates or at least some of them are capable of producing definite dusty lung disease. This disease is termed asbestosis. Although akin to silicosis, the two conditions are distinctly dissimilar in many respects. Much less is known about the nature of asbestosis than silicosis, or the conditions under which it arises. Apparently much larger particle size of asbestos dust or asbestos fibres than is true for silica may contribute to the causation of asbestosis. In the x-ray picture, which is the prime method for making the diagnosis, no characteristic nodules appear, at least no great number, and instead the x-ray picture is characterized by very fine beaded network or lacework of pulmonary markings. Asbestosis is not associated with tuberculosis to the same extent that is true for silicosis. This disease is progressive, but its rate of progression may be even lower than for silicosis. Altogether this disease is somewhat less important than silicosis.

In this plant, asbestos, asbestine, or talc are used in the following departments: Coal Tar, Dry Color, Paint and Varnish and Lacquer.

A small number of asbestos exposed workers were subjected to x-ray examination. The results appear in a special section. Two of these workers appear to present very minor evidences of asbestosis. The condition is so trivial that justification for a diagnosis of asbestosis does not exist. These two workmen should not be apprised of their borderline condition and may be kept at their same work, provided the protective measures later recommended are carried out in this plant. It is the opinion of these investigators that asbestos does not constitute an outstanding practical hazard.

3. Silicates

A variety of silicates find application in various departments in this plant. Chief of these is magnesium silicate, discussed in the preceding item. Apart from this one silicate, no others are known to produce a definitely characteristic dusty lung disease. However, the term "silicosis" enjoys some use. Among other silicates used in this plant in appreciable quantities and in addition to magnesium silicate, are various clays, bentonite, slate flour. In addition, many of the mineral pigments, including ochres, umbers, siennas, etc., are rich in silicates, although not entirely composed of them. Silicates have been associated with silicosis, but it is to be definitely pointed out that many silicates are mixed with free silica. Ordinarily, free silica is responsible for the condition attributed to the silicates. In some measure, some silicates serve to retard the action of silica and bring about silicosis. The nature of this mechanism is not known. Lately it has been contended that barium silicate is a toxic agent. Additional work is required before any stand may be taken in this matter.

In this plant, the use of silicates, apart from asbestos, is such that it is unlikely that any harm may be expected. On the other hand, it is undesirable that workmen be continuously exposed to high concentrations of any dust, even though it be well established that such dusts are non-toxic.

4. Lead

In this plant, the foremost practical hazard is to lead poisoning. Many varieties of lead compounds are made in this plant, all ultimately starting with pig lead. As is well known, the group of lead compounds included as foremost are white lead, red lead, litharge, lead acetate, leaded zinc, various lead pigments, usually produced as compounds with chromium. Also lead is found in the form ofterne plate in the tin can factory, and is manipulated in many fashions in many departments.

Lead chiefly enters the body through the lungs, after the inhalation of lead dust. Lead fumes are less important than lead dust as a source of lead poisoning. Some lead is ingested, being carried into the mouth by fingers, in connection with consumption of food, smoking, chewing tobacco, etc. Ingested lead is only about 1/5 as significant as inhaled lead. Inorganic lead compounds do not go through the skin in appreciable quantities. Some organic compounds do, such, for example, as tetraethyl lead used in the manufacture of ethyl gasoline.

As elsewhere discussed in greater detail, lead is highly distributed throughout this plant. It may be detected in small quantities in offices. Some lead may be detected in the outside air in buildings, manipulating lead in large quantities. The minimum amount of lead that may cause lead poisoning varies from person to person and for any given person depends in large measure upon his own individual body economy. There is, however, no such thing as complete tolerance to lead. Ordinarily it is accepted as a fact that 1.5 milligrams of lead in ten cubic meters of air is sufficient to induce lead poisoning in some workers. This ten cubic meters of air is roughly the quantity of air inhaled by the average workman on an average work day. It is probably true that most workers will not acquire lead poisoning from this low threshold, but instead will require larger amounts before any evidence of lead poisoning is evinced. In our experience, large numbers of workmen have been exposed to such quantities as eight milligrams of metallic lead per day without acquiring lead poisoning. In view of the fact that an occasional worker may respond to very trivial amounts, this standard of 1.5 milligrams has been widely accepted as a standard governing protective measures.

In the case of ingested lead, some compounds are much more toxic than others. This depends upon the solubility of the lead. The more readily soluble preparations are conducive to lead poisoning and vice versa. In the case of lead inhalation, less significance is to be attached to solubilities, as ultimately all lead compounds are dissolved and all are toxic. The old idea that metallic lead is non-toxic is probably not justified. At least in the form of fine dust, metallic lead is later oxidized so that the responses of the body are to lead oxide rather than to metallic lead.

In this plant, making very extensive use of lead, large numbers of workmen have been subjected to certain blood tests, suggestive of lead absorption. In addition, large numbers of samples of atmosphere presumably containing lead have been analyzed. The results of these procedures make up special sections of this report.

Lead in one form or another is used in the following departments of this plant: Tin Can, Pigment Products, Chemical Products, Dry Color, Paint and Varnish and Lacquer.

For the purposes of this report, lead is accepted as the dominant exposure in this plant, which fact is well recognized. Much of the entire program of industrial hygiene must necessarily center about the prevention of worker exposures to lead. At the time of the writing of this report, a fair number of workmen are presenting borderline conditions suggestive of lead poisoning.

5. Chromium

Chromium, in the form of the chromates, oxides and compounds with lead, provides various widespread exposures in this plant. With respect to injury to human beings, chromium is a peculiar substance. First, it is so very slowly hydrolyzed when in contact with tissue that its action may persist over periods of weeks. This is responsible for the well known term "chrome hole", which is a burrowing ulcer more or less jug shaped, with a small opening at the skin surface, but with undermined edges and enlarging area of damage. In the second place, not all of the chromium compounds are harmful. Certain valences yield toxic bodies while others do not. A third peculiarity resides in the fact that chromium, while able to attack the unbroken skin, is much less apt so to do than to attack a skin which is chapped, cut, blistered or otherwise broken. Apart from "chrome holes" of the skin, the chief site of action of chromium is the nasal septum, which is often perforated and irreparably so. This leads to no disability, although septal perforation may lead to disturbing whistling through the nose and may pave the way for sinus and other nasal diseases.

Chromium rarely leads to generalized disease. Some persons may become sensitized to its action so that responses are brought about on the slightest exposure to chromium and at sights other than those in direct contact. It is also true that chrome compounds in the form of dust or vapor may reach lung tissues through inhalation and may set up bronchitis or other inflammatory processes. This is, however, the exception and not the rule. Lately the claim has been made that chromium compounds may lead to cancer of the lung. This is recognized as a remote possibility and in any event the action of chromium will not be more specific than other irritants reaching lung tissues. In this plant, chromium finds some application or manipulation in the following departments: Chemical Products, Dry Color, Paint and Varnish and Lacquer.

6. Manganese

Comparatively small quantities of manganese in a variety of compounds find use in several departments in this plant. Manganese leads to a bizarre disease called manganese poisoning, which chiefly has arisen as a result of exposures to manganese oxides. At this time, there is no reason to believe that other compounds of manganese may not be similarly injurious. When the substance enters the body (chiefly through inhalation of dust), the disease state is brought about, in comparatively short time, such as three months and even less. Naturally, in some measure, this depends upon the concentration of the dust to which exposure is provided. Without any pain or any quick changes, workers exposed to manganese may be noted to develop periods of excessive laughter or crying, unassociated with any adequate cause. At about the same time, it may be observed that their facies become mask-like, immobile, expressionless. At a little later stage these workers, when walking or running, are unable to stop until they run into some object or grasp some projecting structure. They are apt to fall down, particularly when taking steps backward (retropulsion). They are unable to stop their movements until they fall or bump into some object. During this process, these workers may have their mental faculties unimpaired, but are no less totally disabled. In time they become completely paralyzed in portions of the body, such as the arms and legs and may live long lives of total invalidism without any prospect of recovery.

At the time of the writing of this item, no suspicion has arisen that manganese poisoning prevails in this plant. The circumstances of the use of these materials seems to preclude any practical extensive exposure.

7. Tripoli

In this plant, tripoli is commonly referred to as "mixed silicates". These statements probably are not true. Instead, tripoli is a crypto-crystalline variety of quartz and is composed to an extent of about 99% of free silica. The mining of this material is limited, so far as known, to two areas in the United States, namely Southern Illinois and the Seneca area in Missouri, which extends over into Oklahoma. In the latter district, the beautiful rose and cream colored tripolis are found.

Tripolis possess peculiar electrostatic properties so that fine materials thrown into the airglomerate into heavier balls and drop to floor levels. On this account, cases of silicosis from tripoli are rare, although not unheard of.

Since tripoli is in fact quartz, reference is made to item one; in this series, for discussion of the disease that may be produced by it. In this plant, tripoli is used in the following departments, in limited amounts: Lacquer only.

Dust counts have been made in connection with its use and x-rays have been made of selected workmen longest exposed. The results obtained from these procedures are set forth in other sections.

8. Zinc Sulfate:

The raw material from which lithopone is made, as operations start in this plant, is zinc sulfate, received from the Coffeyville Plant, in a dry lumpy state, which is conducive to dustiness. Although lithopone with its content of zinc sulfide is rated as non-toxic, its precursor, zinc sulfate, possesses properties conducive to harm the workmen. This is manifest chiefly in the form of perforation of the nasal septum and low-grade ulceration or at least inflammation of the nasal passages.

Work carried out about ten years ago with zinc sulfate by these investigators revealed a fairly high frequency of gastric or duodenal ulcer, which was attributed to the action of zinc sulfate. Therefore, it is regarded as within the realm of possibility that increased frequency of gastro-intestinal ulcers might arise among zinc sulfate workers in the lithopone industry. Thus far no evidences have arisen, although no real search has been made for this disease.

Zinc sulfate, so far as known, is only handled in the lithopone department in this plant. There workers are supplied with respirators and no substantial exposure is known to exist. No less, this matter is discussed in greater detail in another section devoted to the lithopone department. Barium as a constituent of lithopone is elsewhere discussed.

9. Cadmium:

Cadmium is found in this plant in two dissimilar sets of circumstances. First, cadmium is removed from the zinc sulfate as a preliminary to the manufacture of lithopone. This cadmium is reduced to the metallic state through recovery processes elsewhere described and discussed. The second aspect of cadmium present is in connection with its use as a pigment material in the Dry Color Department and to a minor extent in Chemical Products and Lacquer Departments.

Wherever it may be used, cadmium is a trackorous substance. It is more toxic than lead, but perhaps not ten times as toxic as lead, as is sometimes claimed. One milligram per day, taken into the body, is dangerous. Usually the entry into the body is made through the portal of the respiratory tract, dust or fume entering in this fashion. However, swallowed cadmium may also lead to poisoning. In any event, the manifestations chiefly center about the gastro-intestinal tract, together with some involvement of the kidneys and liver.

In view of the dangerous properties of this substance, various tests have been made, the results of which are elsewhere set forth.

10. Carbon

Many varieties of paint coatings contain carbon for black pigment purposes under a great variety of names, such as lamp black, bone black, cosmic black, etc., etc. Some of these substances at least are of such physical properties as to provoke great dustiness when they are handled. This dust is inhaled and later on the workman's attention may be drawn to the fact that he is spitting up black tinged sputum. This may persist for some weeks after the last exposure. Workers may become highly concerned and attribute all of their respiratory infirmities to an imagined action of this dust.

The facts in the case are somewhat as follows: While no dust is entirely innocuous, carbon is one of the least harmful. Its entry into the body leads to the condition known as anthracosis, a minor abnormality from which all of us suffer. At autopsy every adult will show some signs of anthracosis. Urban dwellers are prone to present well blackened lungs at every autopsy. Apart from this black pigmentation, carbon produces no noteworthy disease. However, attention has been drawn to the fact that some carbon preparations contain oil and that others have been mixed with silica as an impurity. Under such circumstances, it is possible that these extraneous materials may bring about their own diseases, which no less may be laid at the door of carbon. It is the intent of this discussion to rate carbon dust when inhaled as an innocuous material, worthy of little hygienic consideration.

11. Asphalt

Under this term, there are included, for the purposes of this report, many substances that are not natural Trinidad asphalt. These include petroleum and coal tar pitches or residues, Gilsonite, Tailings of various sorts, stearine pitch, etc. Chemically, all of these substances represent mixtures, the exact composition of which is little known. When these substances are in dry state, they present little opportunity for injury from contact. Contrariwise, when they are naturally liquid, or when they have been cut back, or when in liquid state through heating, they are more likely to bring about injury on contact. These substances are sources of skin irritation for some workmen. In contact with the skin, these materials are removed with difficulty. Satisfactory personal hygiene is not easily obtained and in the absence of a real dermatitis, there may slowly develop a condition characterized by numerous large blackheads (comedones), largely the result of ordinary dirtiness. This stage may progress to one of furunculosis, characterized by multiple small boils, abscesses, etc. When such materials are used on roadwork, they are ordinarily heated to high temperatures and the vapors thus arising are highly irritating to the respiratory tract. It is not known that paint manufacture leads to similar operation, but if so this operation should be carried out only in the open or else under hooded conditions.

12. Nitrocellulose

The public entertains a fair amount of apprehension against the action of nitrocellulose. This is unwarranted. At least the nitrocelluloses employed in coatings and in their natural state are free from dangerous potentialities. Nitration has not proceeded to that percentage conducive to explosibility. On the other hand, when nitrocellulose is burned, there may be produced one or more of a series of the oxides of nitrogen, several of which are exquisitely active in producing pulmonary edema and edema of the entire respiratory tract. After breathing a few breaths of nitrogen oxide containing air, sufficient harm is wrought so that a few hours hence, such as 5-18, enormous edema sets in, occluding the passages for air and leading to death of the victim through internal drowning.

The various grades of nitrocellulose used in coating preparations are apt to be received in the wet state, the wetting being brought about by the action of denatured alcohol. In practice, the denaturant much used is wood alcohol, present to the extent of 5%. In the cutting of nitrocelluloses for lacquer purposes, this content of ethyl alcohol and wood alcohol is of no great concern. However, in a few processes, such as the manufacture of lacquer chips, disagreeable work conditions may result from evaporation of large quantities of alcohol in closed areas. Dangerous fire hazards may be produced and on occasion conditions favorable to explosion may arise.

13. Beta Naphthol

One large section of this plant is devoted to the manufacture of beta naphthol. This work is carried out under favorable conditions, and the casual visitor at once gains an unfavorable impression of this operation. Workers in this department make complaints about the disagreeableness of the work, but as yet no one has been able to prove that beta naphthol produces any serious disease. It is irritating to the eyes and mucous membranes, may lead to lachrymation and sneezing, occasionally produces some skin disease; occasionally, cystitis arises in beta naphthol workers.

14. Paraphenylenediamine

In the case of most dyestuffs, the final product is apt to be non-injurious, while intermediates may be quite to the contrary. In the case of paraphenylenediamine, both the intermediates and the final product are worthy of respect. In another section is presented discussion of the manufacture of this dye. It is best known as a dye for hair, fur, feathers, woolen materials, etc. All diamines are said to possess harmful properties, although considerable differences may exist between the actions produced by different members of this group. This dye leads to three different types of manifestation, a) asthma, b) edema, c) skin eruptions. It is not unusual for the wearer of a cheap fur, dyed with this material, to develop extensive swellings of the face, lips, ears, etc. Fur workers in particular may suffer from asthma produced by the dust from furs dyed with paraphenylenediamine. The skin disease created has no special characteristics and resembles many other occupational dermatoses. While no large experience has grown up relative to injuries produced to workmen in the manufacture of this dye, it is no less labeled as an outstanding example of dangerous dyestuffs.

15. Zinc Oxide

This well known substance is blamed for more occupational diseases than it is capable of inducing. As used in the paint industry here, it is almost wholly guiltless and an inert agent. In ointments, lotions, it is perhaps the most widely used of all treatments for skin diseases. High concentrations of its dusts will at most produce nothing more than a harmless increase in the fibrous tissues of the lung. Regardless of the concentration of exposures and its duration, zinc oxide will never lead to a dusty lung disease, analogous to silicosis.

On the other hand, zinc oxide, under certain circumstances, may lead to what is variously known as zinc chills, spelter chills, brass workers' chills, zinc ague, metal fume fever, etc. These conditions which, in fact, are but one, are quite genuine and are due to the inhalation of recently produced zinc oxide, such as arises in connection with galvanizing, brass founding, zinc founding, zinc smelting, etc. Here the zinc oxide in its recently formed state is in a peculiar physical condition known as its "dispersed" phase, in contrast to its "flocculent" state, which is the state of the material found in the paint industry. Thus, the toxic properties of zinc oxide are limited to a few operations which do not include the use of different varieties in paint manufacture.

Titanium, in one form or another, is used in this plant in the following departments: Lacquer, Chemical Products, Paint and Varnish, Lithopone.

19. Aluminum

One of the common materials used in the paint industry is aluminum. These present statements do not apply to aluminum silicate or to other compounds of aluminum, but instead to metallic aluminum. Well known to the paint trade are the scale-like flakes of aluminum which impart to a coated surface a somewhat ideal coating. In view of the fact that some years ago many controversies centered about the toxic properties of aluminum, many persons still regard all aluminum as dangerous. If this were true, the millions of users of food cooked in aluminum vessels would suffer ill consequences. The widespread use of alum in a diversity of trades would have lead to the poisoning of hundreds of persons. The use of alum baking powder would practically have decimated the country. Least of all, should aluminum paints be regarded with concern because of any toxic properties. It is true that aluminum powders possess peculiar properties favorable to fires and explosions. It is true that water is not a repellent to fires of aluminum powder. It is true that the liquids with which aluminum powders may be mixed to make paint may be somewhat irritating. It is true that aluminum powders lend themselves to great dustiness. It is true that in the manufacture of aluminum powders and bronzing powders great noise and vibration of harmful nature is brought about, but it is not true that powdered aluminum in any reasonable quantity will produce any disease analogous to those such as lead, cadmium, arsenic, mercury, manganese, etc.

20. Paraffin

Paraffins as used in the paint industry may exist either as liquids or solids, depending upon their melting points. Naturally the solid varieties may be reduced to liquid states through the application of heat. No real reason exists for classing paraffins as dangerous substances to all persons. When heated, the emitted vapors are nauseating and disturbing. The unheated liquid varieties of paraffin are essentially odorless, tasteless and harmless. Very occasionally, a person brought in contact with paraffin oils will develop a skin disease and even less frequently skin cancer may arise. It is the intent of this discussion more to exculpate paraffin from injurious qualities than to include it in any group of dangerous substances common to the paint industry.

21. Caustics and Soda Ash

The term "caustic" is a loose one and is sometimes applied to acids as well as alkalis. Its use here is limited to such substances as sodium potassium hydroxide and other lye-like substances and includes soda ash. The real caustics, such as the lyes from sodium and potassium readily cause severe burns, leading to the formation of eschars. These dense, core-like centers of caustic ulcers act as foreign bodies and deter all healing processes. Caustic burns of the eyes are especially intractable and call for specialized treatment. Such conditions clearly constitute accidents, but scarcely are to be considered in connection with occupational disease discussions. On the other hand, caustic dusts breathed into the lungs may lead to somewhat extensive fibrous deposits of uniform nature, quite similar to deposits from silicosis. Soda ash in the form of a crystalline powder, in contact with the dry skin, produces no more harm than so much sand. When, however, moisture is present and some of the soda ash is dissolved, particularly in such areas as between the fingers, definite burnings may arise. During hot months or under certain other circumstances, when sweating takes place, acute dermatitis from soda ash may be expected.

22. Phthalic Anhydride

This markedly irritant substance is used in the manufacture of glyptal type synthetic vernishes. In the process of varnish cooking, vapors of this substance prove to be distinctly irritating to the eyes

and respiratory tract. These vapors are changed over into snow-flake like deposits which settle about the varnish department. On occasion these vapors or their subsequent crystals travel several hundred yards in the direction of prevailing winds. Some belief exists that phthalic anhydride's vapors or dusts are both taken into the lungs, paving the way for asthmatic states. If so, this has not been proved and at this time no blame may be laid on this substance other than that as a highly disagreeable local irritant.

23. Synthetic Resins

In this very brief presentation, it is manifestly impossible even to enumerate the several thousand of possible synthetic resins or even to mention the various classes. Two points only are to be made at this time in connection with synthetic resins. The first is that nearly all are proving to possess some degree of activity in promoting skin affections. Some are much worse than others, some through direct irritation, others through sensitization. Bakelite resins may be taken as an example. This condensation product appears to base its irritant action upon the presence of formaldehyde derivatives. At any rate, bakelite, in any of its forms, whether the powdered "Hex" or the dissolved liquid used in fabric coating, constitutes an irritant, damaging most persons brought into contact with it. The second point to be made is that the synthetic resin field is changing so rapidly that as yet the toxicologist knows little about the entire group and only about special examples. On this account, no attempt will be made to specify the more dangerous of the synthetic resin groups.

24. Natural Gums or Resins

The fossil gums and the vegetable resins are relatively unimportant as producers of skin diseases. However, every single one has proved to be the source of some disturbance. Perhaps the most injurious of all is the lined pine resin type. Here the disturbing agent may of course be the line rather than the resin, but in any event this combination is a trouble maker in some plants. On a comparative basis, the natural resins are less dangerous than their synthetic substitutes.

25. Solid Dyestuffs and Intermediates

In order to approach comprehensiveness in this listing of much used solid items in this plant, it is highly desirable that mention be made of a very large group of solid intermediates and dyestuffs. It is manifest that not even their names may be mentioned nor may it be said that a full understanding of many of their properties exist. However, emphasis may be placed upon one observation, namely that finished dye stuffs are far less toxic than their intermediates and precursors.

26. Benzol

Of all fluids used in paint manufacture, benzol has attracted most attention as a toxic substance and perhaps has been the source of a greater number of severe cases. Benzol is a coal tar hydrocarbon, is an excellent solvent for a variety of substances little soluble in ordinary materials. Chief among these is rubber. In fact, most of the cases of benzol poisoning in the early days arose from rubber using factories. So great was the complaint against benzol about ten years ago that its use almost entirely disappeared in the paint industry, except in the manufacture of paint and varnish removers. Nothing seemed to take the place of benzol in this particular preparation. More recent times have seen an increasing use of benzol in the coating industry, as is reflected by the fact that at this very plant a benzol producing department is being built with a capacity of about 1500 gallons per day. One reason for the return of benzol is the shortness of memory of man for his troublesome experiences of all types. The second is a willingness on the part of the manufacturer to install protective equipment to carry out supervised laboratory procedures. It is in truth much safer to make use of benzol at the present time than was true

eighteen years ago. At the present time it is possible to carry out a urine test, known as the "urine sulfate" test for benzol and from the results obtained to detect those workers who are absorbing appreciable quantities of this substance.

Benzol may act as an acute poisoning, operating as an anesthetic or asphyxiant and may bring about death within a few minutes or a few hours' exposure. More often benzol poisoning is chronic, leading to a disease characterized by leukopenia, diminished agglutinability of the blood, peculiar susceptibility to all infections, tendency to hemorrhage, profound weakness, etc. The condition produced is direful, there being little tendency for the blood to regenerate, leading to what is known as an "aplastic anemia". A few persons develop hemorrhages into the eye and suffer complete blindness. A greater number die from inter-current infection. Women seem to be somewhat more seriously affected than men.

It is the intent of this discussion to emphasize but not exaggerate the importance of benzol as a source of serious occupational disease. Tests made of the urine of several workers handling benzol at this plant indicate that a few are absorbing benzol. The appearance of a serious case of benzol poisoning at any time would not be phenomenal for this plant. Benzol is used in considerable quantities in the following departments: Coal Tar, Chemical Products, Paint and Varnish, and Lacquer.

Other sections of this report furnish additional information on benzol poisoning.

27. Toluol (Toluene)

Toluol is a homologue of benzol, but possesses a higher boiling point, is thus less evaporable and is less likely to produce vapors which may be inhaled by workers. Some confusion exists relative to the clinical state produced by toluol. Some observers maintain that toluol vapors if present in quantities the same as benzol will produce a disease similar to benzol poisoning and is only less poisonous than benzol because of its higher boiling point. On another side, some observers point out with accuracy that there have been very few cases of toluol poisoning and that really no one knows just what disease state might be produced. These observers note that toluol appears to be capable of producing an acute asphyxiation more readily than benzol, but is lacking in properties to produce leukopenia or other blood disturbances. Granting the absence of adequate information, the stand is taken by these investigators that toluol is a much preferred substance over benzol because of its higher boiling point, but that toluol itself is a highly dangerous substance and produces a condition at least similar to benzol poisoning, if not identical in its features.

28. Xylol (Xylene)

Xylol is another homologue of benzol in the same series with toluol. Its boiling point is even higher than that of toluol and to that extent is less toxic. All that has been said of toluol may proportionately be said of xylol. Very little is known about its toxic properties and very few cases have been well studied. Its physical properties do not make it a perfect substitute for benzol, but no less it finds extensive application in many industries. The urine sulfate test mentioned under benzol is not known to apply to toluol or to xylol. However, it is believed that leukopenia so readily demonstrated through blood counts, probably may be shown for xylol poisoning as well as benzol poisoning, which finding may tend to confirm a tentative diagnosis of xylol poisoning.

29. Solvent Naphtha

Solvent naphtha, unlike naphtha, is derived from coal tar in contrast to petroleum oil. Earlier solvent naphtha was chiefly a mixture of benzol, approximately 50% with lesser amounts of toluol and xylol. Nowadays the specifications for solvent naphtha are so altered as to provide practically no content of benzol and higher percentages of toluol and xylol along with other related substances. Solvent naphtha is therefore much less toxic than formerly and is less likely to resemble benzol poisoning, which it formerly resembled, than toluol and xylol poisoning. The chief point to be made in this present discussion is to point out that solvent naphtha is not analogous and comparable to ordinary naphthas, but is a much more dangerous coal tar derivative akin to toluol.

30. Naphtha

In the discussion of this petroleum derivative, there is a desire to include all other petroleum derivatives of similar nature, such as the misnamed "benzine", gasoline, kerosene, hi-flash naphthas, etc. For a long while these substances were regarded only as capable of bringing about an occasional case of skin disease through defatting of the skin and an equally occasional "naphtha jag", which is an acute mental state resembling alcoholic intoxication. More recently increased information has led to the concept that both acute and chronic conditions may be produced by these solvents, both of which are of fairly serious nature; although less fireful than benzol poisoning, the poisoning from naphtha may be wholly disabling. The acute condition is relatively unimportant and is chiefly manifest by gastro-intestinal disturbances, nausea and vomiting, together with headache. In the chronic state, a bizarre lot of changes may take place in the central nervous system, giving rise to a disease more or less like multiple sclerosis. In fact, it is probable that in this disease some sclerosis of the brain takes place. Afflicted workmen develop various paralyses, unusual gaits, lose their familiarity with their surroundings, at times may suffer from uncontrollable sleepiness.

The import of this comment is to include naphthas in connection with those work places where consideration should be given to the possibility of harmful vapors.

31. Acetates

A wide variety of acetates are used for solvent purposes in this plant. These agents are all comparatively innocuous, but none are entirely harmless. There is some reason to believe that the more harmful acetates are methyl, butyl and isopropyl. Synthetic acetates are apparently more toxic than their natural counterparts. The irritant properties of these acetates are chiefly limited to minor inflammation of the eyes, mucous membranes, less frequently of the skin, etc.

32. Cellosolves

A typical cellosolve is ethylene glycol monoethyl ether. All experience tends to indicate that none of the cellosolves are toxic except in high concentrations and that their actions are about on a par with those of acetates. Like most other substances, apparently ethyl cellosolve is the mildest with the methyl, butyl and propyl being of somewhat higher order.

33. Methanol

Methanol, the modern counterpart of wood alcohol, possesses all of the injurious properties of the traditionally dangerous wood alcohol.

This substance is so dangerous that the swallowing of one teaspoonful has produced death. Unlike ethyl alcohol which easily breaks down into non-toxic components, methyl alcohol does not readily decompose nor is there any known physiologic mechanism through which the body may freely eliminate this substance and without injury. Apparently nature in its economy contemplated the coming of ethyl alcohol, but neglected to make any provisions for the management of wood alcohol. At any rate, wood alcohol remains in the body to a considerable extent, being only slowly excreted by the kidneys. Injury may be done to the optic nerve leading to blindness, to the central nervous system, may involve the kidneys, liver, lungs and other tissues. In addition, methyl alcohol is thoroughly capable of bringing about disturbing skin lesions. Moreover, methyl alcohol passes through the skin with fair freedom so that systemic disease may be produced merely by skin contact with this agent. To the full extent possible, methyl alcohol should be kept out of paint, paint removers and all other coatings, both for the sake of the workman manufacturing the products and the ultimate applier of the coating material.

34. Butyl Alcohol (Butanol)

This alcohol is more toxic than its ethyl counterpart, less toxic than methyl. In concentrations above 100 parts of its vapors per million of air, some ill effects may be brought about if exposure is prolonged. In general its effects are about midway between ethyl and methyl alcohol, but apparently it lacks the capacity to produce blindness.

35. Cresols

These coal tar derivatives are similar to phenol in their action. They are readily absorbed by the skin and on the skin produce the same sort of devastating action leading to gangrene. The boiling point of cresols is so high that they do not appreciably evaporate at room temperature. Thus direct contact is almost requisite to damage. Taken internally, cresols quickly produce death, but this has little or nothing to do with industrial toxicology.

In a number of substances, such as water gas tar, possibly asphalt and a variety of related substances, at least one of the constituents is cresols. The presence of cresols appreciably adds to the toxic properties of these complex mixtures.

36. Cresote Oil

Fortunately, little necessity exists for any direct contact between the person of the worker and a great variety of his chemicals. In the case of dusts in the atmosphere, the workman, in the absence of a worn respirator, is unable to escape some contact. This is equally true of gases in the inhaled air, but in the case of liquids, particularly those which do not readily evaporate, a fair degree of safety is provided through little necessity of contact. This applies, for example, to cresote oils, which are substances of varying composition, but which at least contain some cresols, tarry acids and other phenolic bodies.

37. Sulphur Dioxide

This gas is not a raw material, but is the result of the manipulation of other raw materials and may be present in the Chemical Products Plant, the Dry Color Plant, Lithopone manufacture and in a few other places to a minor extent. This is one of the most irritating of gases, since ten parts per million is about the upper limit of safety, 100 parts per million being exceedingly dangerous. This sulphur gas acts on the tissues of the respiratory tract, leading to intense inflammation and ulceration, most of which is acute, but eventually a chronic state may be brought out. Most

workers exposed to sulphur dioxide appear to acquire a tolerance so that they no longer cough incessantly like the visitors or new workmen. The explanation is to be found in the fact that the inflamed respiratory tissues seek to protect themselves by secreting a mucous protective coating, which is unresponsive to the action of this gas. However, below this artificial barrier, tissues remain which are just as sensitive as ever.

This item is here introduced, along with a few others, for the purposes of indicating that now always are exposures to be found in the raw materials being fabricated. Unexpected waste products are sometimes more dangerous than the substances being manipulated.

38. Hydrogen Sulfide

Of all gases present about this plant and not excepting cyanide gases or vapors, the most dangerous is sulphuretted hydrogen. This gas in any quantity that may be measured is toxic, although the mere detection of this gas as an odor is no proof of its toxicity. When quantities are sufficiently high as to be toxic, ordinarily the sense of smell is so desensitized as to escape the odors for other than short periods. At the time of writing this item, tests were being made throughout the plant, looking for its presence. One place showing considerable concentration appears to be in the barium kiln room and in connection with the black ash. Workers in these areas complain of this gas and by actual tests objectionable quantities have been established as present. In another section of this report, recommendations will be made looking forward to the dispersion of this gas so that dangerous concentrations are nowhere present.

39. Formaldehyde

In various reports placed at our disposal, reference is made to the extensive use of formaldehyde in some instances and to formalin in others. Since formalin is a 40% watery solution of the gaseous formaldehyde, and since formaldehyde rather readily leaves this watery solution, no attempt is here made to distinguish between the action of formaldehyde and formalin, except to point out that formalin is a definite skin irritant. Formaldehyde is a highly dangerous gas, exercising injurious action in low concentrations, such as 50 parts per million. It is distinctly irrespirable, leading to profound damage to the respiratory tract, later to the liver and kidneys. The action of formaldehyde is akin to that of wood alcohol—in fact it is into formaldehyde that wood alcohol decomposes when within the body. It is the intent of this discussion to include formaldehyde as a raw material used in this plant in appreciable quantities, as an agent worthy of respect.

40. Nitrogen Oxides

The oxides of nitrogen are of course not raw materials used in this plant, but may arise as extraneous gases from the manipulation of other raw materials or in the presence of unexpected happenings, such as fires. There are perhaps as many as seven oxides of nitrogen, all of which are toxic, except nitrous oxide, which is the well known laughing gas anesthetic. When these gases enter the lungs, they may cause no immediate disturbance, but after a few hours lead to very profound swelling of lung tissues, along with tissues of bronchial passages until the entire respiratory tract is water logged; normal breathing function is lost; death takes place. In this plant, several of the operations connected with dry color production, chemical product manufacture, do lead to these vapors, which on occasion are visible. As noted in connection with nitrocellulose, the burning of this agent leads to the giving off of oxides of nitrogen. Furthermore, whenever nitric acid comes in contact with organic material, these vapors are likely to be evolved.

41. Mineral Acids

In this category, for the purposes of this discussion, will fall sulphuric, hydrochloric, nitric and hydrofluoric acids. Of these, all, in themselves, are the causes of accidents rather than occupational diseases. Of the entire lot, hydrofluoric acid is the most dangerous; for practical purposes, the nitric acid, more so, since hydrofluoric acid is very little used. The properties of mineral acids are such that they do not readily evaporate so that the presence of acid vapors are not of frequent occurrence. However, in the most fortuitous circumstances, these vapors do arise. For example, if sulphuric acid in watery dilution is highly heated, the acid leaves the solution along with water vapors. The water evaporates, leaving the acid vapor in the air. All mineral acid vapors in more than traces are irritants, leading, under the mildest of injurious circumstances, to irritation of the eyes and nasal passages, under more severe circumstances to erosion of the teeth, severe bronchitis, pulmonary edema, and occasionally to gastric ulcers or at least gastro-intestinal dysfunction.

42. Organic Acids

It is quite impractical here to list the numerous organic acids used in this plant. Acetic acid may be taken as an example. Concentrated solutions in direct contact with the skin promptly cause chemical burns with rapid destruction of tissues. Inhaled as a vapor, prompt action is brought about on the respiratory tract, characterized chiefly by bronchitis and pulmonary edema.

43. Turpentine

All turpentine are toxic, be they gum spirit, Kraft distillate, steam distilled or destructively distilled. Of all varieties, it seems established that the steam distilled is generally the most irritating. This statement certainly was true a few years ago, but lately such improvements have been made in the manufacturing processes of steam distilled turpentine that the statement may not apply. All turpentine are skin irritants; all turpentine are potential sources of acute nephritis. A peculiar feature in connection with turpentine action is the pleasant odor of violets imparted to urine whenever turpentine is being secreted.

44. Anilin

One of the outstanding dangerous materials in this plant, particularly in the Chemical Products Plant, is anilin or as sometimes called, anilin oil. The damaging properties of this substance may persist through many chemical manipulations until ultimate dyes are produced, whereupon the finished dyes are more likely than not to be free from toxic potentialities. With some exception, anilin dyes are innocuous, but anilin and many of its close derivatives and compounds are disturbingly so. Physically this agent is a thick, brownish fluid, arising when nitrobenzol is treated with hydrochloric acid in the presence of a metallic catalyst. The oil may enter the body through the skin or may give rise to poison through the inhalation of its vapors, may be inhaled in some of its compounds in the form of dust and under some circumstances may be swallowed. In very mild acute cases, workers may complain of or present some of the following manifestations: Pallor, with or without cyanosis, weakness, dizziness, unsteady gait, confused speech, mental irritability, rapid pulse and varying types of mental disturbances. In some, the disease leads to a condition resembling alcoholic intoxication with loud, confused speech. Others demonstrate loquacity with imperfect orientation, etc. In more serious cases of acute nature, cyanosis may be profound, pulse rapid, bounding, high rate of respiration, with oxygen starvation, vomiting and generally lowered mental and nervous responses. During this stage, blood may appear in the urine. In the most serious cases, such manifestations pass over to unconsciousness, with or without convulsions, and death within a few hours.

may be somewhat different. The following have been observed: anemia, slow pulse, gastro-intestinal disturbances, including loss of appetite, vomiting, diarrhea, skin eruption, headache, inability to sleep, muscular pains, altered disposition, general lowering of mental capacities.

45. Phenol (Carbolic Acid, hydroxybenzene)

This agent is a corrosive poison, leading to gangrene after local contact and also produces degenerative changes in the blood with marked destruction to liver and kidney tissues. It further produces the general constitutional symptoms shared with the nitro derivatives of the benzene group.

46. Nitrobenzol or Nitrobenzene

Nitrobenzol or nitrobenzene is obtained by the action of nitric and sulphuric acids upon benzol. This much used chemical readily enters the body through the skin as well as through the respiratory tract. The poisoning produced has as its chief objective sign profound cyanosis. Other manifestations are nausea, vomiting, dizziness, headache, weakness, burning sensation of the skin, all of which occur in the mildest of cases. In some serious cases, in addition to the foregoing, there may be a marked restlessness, formication, ringing in the ears, loss of coordination, confused speech, drunken type of gait, convulsions, etc. In the more chronic cases, there may appear jaundice, blindness or partial loss of vision, blood changes, etc. Then death arises, a long period of unconsciousness may be preceded by active convulsive periods.

47. Animal Oils

In many paint plants, the blowing of kenehaden oil or other animal oils, gives rise to offensive odors, rather than to any intoxicating products. Even in the absence of blowing operations, some oils may be offensive. When animal oils are heated to high temperatures, acrolein may be produced, which aldehyde is exquisitely irritating to the eyes and mucous membranes.

48. Chlorine

Chlorine gas is reported as only in limited use in manufacturing processes at this time. No argument is required to maintain that the inhalation of this gas even in low concentrations is undesirable. War experience taught the medical profession a great deal about the nature of chlorine injury. It is fairly well agreed that chlorine chiefly attacks the respiratory tract, leading to inflammation in proportion to the extent of concentration of the gas. In very dilute quantities, this gas may lead to minor irritation of the eyes, nasal passages and respiratory tissues. Increased amounts may produce pulmonary edema with hemorrhage and ulceration. Under ordinary circumstances, recovery is prompt and after recovery no chronic effects persist. However, repeated low-grade exposures may lead to chronic bronchitis associated with emphysema. Some workers so afflicted become so fatigued on minor exertion that no longer are they able to carry out sustained physical work.

49. Cyanides

In the manufacture of Prussian blues, and certain other products, certain constituents represent cyanides. Ordinarily, no difficulty is encountered in terms of health exposures, but under fortuitous circumstances cyanide cases may be produced. For example, spontaneous fires sometimes arise in connection with blue pigment manufacture, leading to the evolution

of much cyanide gas. This gas, like hydrogen sulfide, is toxic in most any concentration that may be detected. The following table indicates the order of toxicity:

	Parts of Hydrogen Cyanide per Million Parts of Air
Slight symptoms after several hours exposure....	20 to 40
Maximum amount that can be inhaled for 1 hour without serious disturbance.....	50 to 60
Dangerous in 30 minutes to 1 hour.....	120 to 150
Rapidly fatal.....	3,000

Cyanide gas leads to asphyxiation of a type just opposite to that produced by carbon monoxide. In the latter, the combination between hemoglobin and carbon monoxide deprives the blood of its mechanism for the transportation of oxygen to all portions of the body. In the case of cyanide, the oxygen carrying medium may be intact, but the receiving end of the system may be disrupted and these cellular tissues are unable to make use of the oxygen delivered by the blood. The ensuing results are known as internal asphyxiation, which action is characteristic of a number of chemicals, including cyanides.

50. Skin Irritants

In liquid, solid and gaseous materials there may be found scores of agents that readily produce skin diseases of diverse sorts. It is possible that in this plant a list of no less than 500 substances might be made up which in the published literature on industrial toxicology have been recorded as true sources of skin diseases. Actually, in this plant, very few instances of skin diseases are known to have arisen over a period represented by the past several years. In spite of this fact, it is necessary to rate skin exposures as the outstanding hazard on a numerical basis in all portions of this plant. This situation has led to a special section of this report devoted to skin diseases. No less, this minor comment is introduced into this present series of fifty noteworthy items as an introduction to more extensive discussions found elsewhere.

51. Barium Sulfide

For good measure, barium sulfide is here included because in any list of fifty practical items in this plant this chemical stands out as exceedingly troublesome. Although barium in lithopone starts and finishes as a sulfate, the intermediate stage represents the sulfide probably together with some barium oxide. This change is produced in the black ash kiln, as is well known. The barytes as received may contain much lead as an impurity. However, this lead is lost in the refining processes, being either evaporated due to kiln action or removed during the leaching processes. The temporarily produced barium sulfide together with the possible barium oxide admixture is highly irritating to the skin, eyes, and mucous membranes. It readily leads to dipilation. Theoretically, barium possesses some radio active properties which might lead to lung cancers. Also, the irritant action of the sulfide conceivably might stand in relation to the causation of serious lung diseases, chiefly of the inflammatory type. Elsewhere in this report further discussion is presented about barium sulfide and definite recommendations have been made for bettering work conditions.

In connection with the manufacture of barium sulfide, there exist in addition to its own exposure, exposure to hydrogen sulfide, sulfur dioxide, excessive heat, and, as mentioned above, lead.

OUTSTANDING EXPOSURES IN THIS PLANT BY DEPARTMENTS

Tin Can

Lead fume, lead oxide fromterne plate, noise, zinc chloride, hydrochloric acid flux vapors, minor skin irritants.

Pigment Products

White lead dust, red lead dust, litharge dust, zinc sulfate dust, metallic lead fume, carbon dioxide, hydrogen sulfide, cadmium vapors, leaded zinc dust, acetic acid vapors and direct contact, soda ash dust and solution, heat, sulfuric acid, phthalic anhydride, mineral spirits (naphtha), numerous skin irritants, barium sulfide.

Coal Tar

Asbestos, caustics, asphalt, benzol, various tars and pitches, naphtha, light oil, cresols, including tar acids.

Chemical Products

Anilin, anhydro-formaldehyde anilin AFA, methyl anilin, formaldehyde, chlorine (in fuchsin and product of chlortoluidine sulphonic acid in Tobias Plant), diamines (chiefly paraphenylenediamine in Tobias Plant), nitranilines, beta naphthol, acid in alkalies, xylidines (in Azo manufacture), nitric acids (in Azo Plant), arseniuretted hydrogen, acetanilid, toluol and its derivatives, xylol, benzol and its derivatives, such as nitrobenzol-, sulphur dioxide, ammonia, manganese, strontium, barium, beta oxy naphthoic acid, lead compounds, various chromate compounds, soda ash, sulfites, quebracho, trisodium phosphate, all chlorinated compounds, all nitro compounds, all phenolic compounds, noise, intangible exposures associated with crowding, poor arrangement, poor ventilation, makeshift structures, inadequate exhaust systems.

Most important of all are "mixed exposures", potentially leading to mixed intoxications without clear-cut diagnostic features and generally troublesome.

Dry Color

Lead (many varieties including sulfate, carbonate, chromate, acetate, nitrate, lead oxides, etc.), chromium compounds (including chromates, oxides), barium compounds, cadmium compounds, silica, asbestos, methanol, butanol, toluol, xylol, naphtha (several varieties), molybdates, tungstates, nitranilines, beta naphthol, toluidines, acetanilid and its alkalies, xylidines, organic acids (such as oxalic), soda ash, all cyanide compounds, sodium phosphates, dry ice, all manganese compounds that give rise to dust, all cadmium compounds that give rise to dust, solvent naphtha, non-specific exposures related to over-crowding, poor arrangement, ancient structures, unnecessary hand work, poor illumination, etc.

Mixed exposures, potentially leading to "mixed" intoxication, no two of which are apt to be identical.

Above lists for Chemical Products and Dry Color are but representative and are far from exhaustive. A much longer list might be made up presenting possible sources of skin injury.

Paint and Varnish

Silica, lead compounds, asbestos, talc, chromium compounds, manganese compounds, caustics, arsenic compounds, oxalic acid, asphalt, pitches, tars, gilsonite, antimony compounds, cadmium compounds, fluorine compounds, synthetic resins, phthalic anhydride,

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formaldehyde, dry ice, all compounds containing free anilin, all nitro compounds, toluidines, turpentine, benzol, toluol, xylol, methyl acetone, ammonia, butanol, naphtha and all petroleum derived solvents, all phenolic oils and compounds, including creosote oil.

Another list might be made up of what might be termed second class exposures and still further a very long list might be compiled indicating substances capable of inducing occupational dermatitis. At least half the substances used in this department have on occasion produced dermatitis.

Lacquer

Silica, asbestos, including asbestine and talc, all lead compounds, all chromium compounds, all asphaltic bodies, pitch, tars, all antimony compounds, benzol, wood alcohol, synthetic resins, fish oil, all toluidines, manganese compounds, cadmium compounds, all ketones, acetones, all chlorinated compounds, wood alcohol, tripoli, turpentine, naphtha, including all petroleum solvents, benzol, toluol, xylol, solvent naphtha, all mineral acids, all organic acids, formaldehyde, butanol, tricresyl phosphate, all synthetic resins, cellosolves.

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Specimen Formulae for Coating Compounds, Thinners,
Bases, Etc., together with a Discussion of the Toxicity
Resulting from Complex Mixtures

Foremost, the preceding discussion deals with individual chemical substances and fairly simple mixtures. Thus, comment has been made upon such basic substances as benzol, toluol, ethanol, butanol, silica, naphtha, manganese, chromium, lead, cadmium, etc. In paint work, it is inevitable that much activity will center about the use of mixtures of various types of solvents, thinners, bases, etc. On this account, there is now presented a series of formulae showing the composition of a variety of compounds utilized in the making of still more complex products. After the listing of these formulae, brief discussion is provided concerning the toxicity of these compounds.

Representative Formulae

- | | |
|----------------------|-------------------------------|
| 1. Lacquer Base #225 | 25# 10109 Para Toner, Deep |
| Deep Para Red | 12# (115) Raw Castor Oil |
| | 28# (1620) Dibutyl Phthalate |
| | 24# (1651) Ester Gum Solution |
| | 15# (1519) Damar Gum Solution |

Of these five ingredients, three still represent compounded articles, namely (10109), (1651) and (1519). Thus (10109) Para Toner, Deep, is made up of an organic color and calcium carbonate. The Ester Gum Solution consists of 650# of ester gum and 350# of (584) xylol and further Damar Gum Solution consists of 474# of 1239, Damar Gum, plus 185# of (584) xylol plus 341# of (350), which is 95% ethyl alcohol.

Thus it comes about that under the somewhat innocuous term "Deep Para Red" there lurks the possibility that in the successive stages of manufacture there conceivably might be brought about distinct exposure to two substances definitely known to be toxic, namely toluol and xylol, together with a number of minor exposures.

- | | |
|-------------------------|-----------------------------------|
| 2. Thinner 04516 (1628) | 110 gals. (140) Benzol |
| | 50 gals. (2611) Isopropyl Acetate |
| | 10 gals. (1167) Butyl Alcohol |
| | 50 gals. (1170) Butyl Acetate |

Under this term "thinner", use is made of four solvent materials, all of which are known toxic agents and two of which are distinctly dangerous. However, it is noted that the very formula carried reference to "caution" as required in connection with the use of benzol.

Since this formula may not be taken as representative, the formula for a second and more widely used thinner is here shown in the following item:

- | | |
|---------------------------|--|
| 3. "B" Grade Thinner Acme | 207.5 lbs. (1170) Butyl Acetate |
| Use, (1616) | 49 lbs. (2611) Isopropyl Acetate |
| | 81.5 " (1686) Special Naphtha Driolene |
| | 109 " (584) Xylol |
| | 241 " (241) Toluol |
| | 27 " (1167) Butyl Alcohol |

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Again it appears that in the more or less standard thinners, liquid substances capable of fairly ready evaporation widely are used. This comment stands distinctly in relation to the complaints being made by these investigators about the undesirable work conditions in the Lacquer Department.

4. (1696) 1/2 Sec. Base Lacquer (Cotton Solution)

415 lbs.	1226	1/2 sec. Nitrocellulose
106 "	(2611)	Isopropyl Acetate
166 "	(1170)	Butyl Acetate
28 "	(1167)	Butyl Alcohol
15 "	(330)	Grain Alcohol
225 "	(241)	Toluol
45 "	(584)	Xylol.

Again the comment made be made that such a cotton solution potentially involves exposure to dangerous solvent material.

5. (2619) T-245 Gum Solution V-8632

374 lbs.	T-245 Rezyl Gum
95.5 "	(1170) Butyl Acetate
95.5 "	(2611) Isopropyl Acetate
280 "	(241) Toluol

6. Lacquer Tint 507, Canary Yellow

142 lbs.	L.E. 207
14 "	(1651) Ester Gum Solution
59 "	(1519) Damar Gum Solution
613 "	(1807) Cotton Solution
52 "	(1616) Solvent Base B

Of the foregoing five ingredients, themselves representing complex compounds, all require still further analysis in order to reach the individual constituents. In this case, further analysis is not here listed to save space, but the point remains obvious, that in all instances widespread use is being made of substances, the toxicity of which is well established.

7. Synthetic Base 507, Deep Green

.5 lb.	547	Aluminum Stearate
16 3/4 "	11024	Milori Green
19 1/4 "	11025	Chrome Green (light)
8 "	1195	Bone Black
9.5 "	1538	Zinc Sulphide
47.5 "	(2142)	Synthetic Oil Mixed Varnish

(2142) is (1257) high flash naphtha and (3085) para thinner. In turn, certain of these ingredients may further be broken down.

Here again, under terminology that discloses no hint as to possible dangerous material, we are dealing with lead compounds, chromium compounds, high flash naphtha and other substances of potentially harmful properties.

The objective in mind in presenting this discussion of the make-up of compounds is to point out that with practically every ramification of paint, varnish, lacquer and other coating manufacture, theoretical opportunities for exposure almost regularly exist. It is not argued that actual and practical exposures prevail, but instead it is maintained that these toxic compounds, being so widely spread, might, on occasion give rise to cases of occupational diseases at almost any point in the plant.

The Toxicity of Mixtures of Harmful Substances

In the world of industrial toxicology, much is known about the dangerous properties of a great variety of individual substances, including liquids, solids, dusts, vapors, gases, mists, etc. Ways and means have been devised for measuring the concentration of these various agents under diverse circumstances. When, however, these substances are found as mixtures in the atmosphere and particularly as mixed gases or mixed vapors, an enormous lack of information exists.

It is well nigh impossible, with any of the equipment and procedures now available, readily to measure on a percentage basis the presence of such vapors as those from benzol, toluol, ethyl alcohol, butyl alcohol, isopropyl acetate, glycol, when these substances, or any similar grouping, co-exist. With reasonable certainty, the extent that various constituents of a vaporous mixture may be estimated from a knowledge of the respective chemical and physical properties. However, in complex mixtures, this accuracy may still provide for a thirty or fifty per cent error.

Equal difficulty is encountered in delineating the effects of individual members of a group of mixed vapors or gases. To some extent, the action of one particular constituent may mask the manifestations of harmful action of some other constituent. In industrial hygiene work, this situation gives rise to a well recognized but little known field of mixed intoxication. Such a situation exists in the Lacquer Department of this Plant. Here it is known that a very high concentration of mixed vapors is widely present, but it is not known that this vapor concentration is paramountly made up of any one vaporous material present, such as toluol, xylol, butanol, ethanol, naphtha, acetates, or others.

By common consent, under such circumstances, much significance is attached to the most toxic body present in a mixture and to assume that at least a portion of the vapors present arise from this outstanding agent. In the case of the Lacquer Department, such significance is to be attached to toluol and butanol. Because of the inability precisely to measure quantitatively the presence of harmful vapors in mixtures of vapors, it becomes necessary to stress the importance of providing preventive appliances and practices such as will largely eliminate the entire lot of disturbing vapors or gases, or dusts.

X-RAY EXAMINATIONS

Because silica, asbestos, asbestine, talc and tripoli, various silicates, and other silicious materials are used in this plant under conditions conducive to dustiness and in fact under conditions of known dustiness, it was deemed desirable to make x-ray examinations of the chest of a small number of men longest exposed.

Accordingly, 19 men were sent to the Roseland Community Hospital and were examined by Dr. H. A. Petersen. The names of these men now follow, together with minor history items reflecting the nature and extent of exposures:

<u>Badge No.</u>	<u>Name</u>	<u>Operation</u>
12		Mill Dressing, Paint and Varnish
44		"
119		"
219		"
1729		Lithopone bagging
1945		"
1717		Unloading zinc sulfate
629		Asbestos filling; coal tar plant
630	REDACTED	"
642		"
1735		Barium Department
1739		"
2469		Tripoli filling, Lacquer
2490		"
2453		Silica filling, Lacquer
2498		"
2504		"
2520		"
222		Former Mill Dresser

The x-ray films were interpreted by Dr. Petersen, Dr. Hess and Dr. McCord. One typical report is here appended, indicative of the nature of the examination and findings. Similar reports are in Dr. Hess's possession on all of these examinees. The corresponding films are retained by the Roseland Hospital, but are available should the need arise. These films were made through the use of new, very modern x-ray equipment, at six feet distance, 0.1 second time, with an amperage up to 300 as required, and were made in stereo.

Dr. McCord's Comment on the Dusty Lung Disease Situation:

1) From all these examinees for silicosis, not one suggestive finding has been made. It is possible to state that there is no proof

that the silicious materials used in this plant are bringing about any known injury to any workman in terms of silicosis. If a case of silicosis should be detected among the workers of this plant, it may be anticipated that this disease state was produced by exposures in other industries or possibly under other conditions that may have obtained in this plant in bygone years.

2) Among the examinations obtained from those workers exposed to asbestosis (magnesium silicate), two men were found who barely suggest a possibility of asbestosis. It is possible that no warrant exists for taking any notice of these theoretical conditions. Certainly these two workmen should not be told that they suffer from asbestosis, as undoubtedly they would be alarmed, when no alarm is in order. On this account, the names of these workmen are not even recorded, as it is expectable that they may live full lives without any disability and without any knowledge of their possible trivial impairment. No less, this observation prompts certain recommendations made with reference to additional protection against dustiness wherever asbestos is used in large quantities in this plant.

3) The reason for the absence of silicosis among workers handling silica is probably to be found in the intermittency and irregularity of exposures. If dust counts were made and certain dust counts were made, at the immediate time of emptying bags of silica into mixers, grinding equipment, etc, high dust counts would be and were found. However, it must be remembered that this work may be carried out only two or three times per week and only for an hour or two at a time. This is the saving factor in connection with the absence of silicosis in the paint industry as observed by us in several plants. The work is too irregular and the exposure is too limited to serve as sufficient cause to bring about silicosis.

4) In spite of the genuine absence of any disabling dusty lung disease, the management must recognize the possibility of certain legal compensation hazards. Almost any one of the examinees above dis-

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cussed, should he so desire, could present a claim alleging a dusty lung disease and could in truth show on his x-ray film considerable quantities of scar or fibrous tissue. Such cases as these, if tried before juries, are almost invariably awarded money. Here in Illinois, where such claims would be presented before compensation boards operating under the Occupational Disease laws, it is unlikely that consideration would be given to these meritless claims. No less, considerable expense might be involved in defeating these spurious conditions. This leads up to the point that even though no silicosis is present and none is in prospect, it is desirable that an effort be made to eliminate all possible silicious dusts throughout this plant, when equally useful substitutes may be applied and to manipulate indispensable silicious material with due precaution as to exhausts and the wearing of respirators.

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Roseland Community Hospital

ROENTGEN DEPARTMENT

Room Out

Date 10-15-57

McCord
Drs. &
Bess

REDACTED

Sherwin Williams Co.

Name:

Age 22 years

Ck. #2498

Examined for: (Occupation as Silica filling, Lacquer Department
(Lungs) Stereo—radiographic and fluoroscopic

Roentgen Findings:

Is there X-Ray evidence of:

Active tuberculosis? No

Early, healed or quiescent tuberculosis? No

Pneumoconiosis in any form? No

Extensive linear fibrosis? No

Nodular fibrosis? No

More than normal amount of fibrosis? No

Marked accentuation of the bronchi? No

Any departure from normal respiration? No

Any lung disease, including non-tubercular pathology? No

Pleural adhesions, empyema, emphysema, or pneumothorax? No

Give in detail the condition of lungs as shown by X-rays:

This is a rather long chest, reasonably symmetrical. The heart and aortic arch are within normal limits. There is a slight upward angulation of the outer portion of the left side of the diaphragm which resembles that due to a pleural adhesion. Otherwise the diaphragm is regular and both costophrenic sinuses are clear. The excursions of the diaphragm are equal and good.

The root-shadows and lung markings are within normal limits. In the hilums there are a few calcified areas. Neither lung field contains any definite evidence of pneumoconiosis or active tuberculosis.

A. J. Petersen, M.D.

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DUST COUNTS

In a plant of this character no need arises for the making of large numbers of dust counts. Several reasons for this statement exist. The more dangerous dusts better may be appraised through chemical analyses; in some instances dust clouds are so dense that it is unnecessary to make dust counts in order to prove the presence of excessive dust concentrations; a number of dusts, particularly in the Chemical Products division, are water soluble and thus do not lend themselves to ordinary dust count procedures.

On the other hand, a limited number of dust counts will be helpful in order to provide evidence of exceedingly high concentrations. Accordingly, samples have been taken at a few work points where lithopone, silica, black ash and asbestos are used. The results obtained appear in tabular form at the end of this section. Also there is there presented one specimen dust count sheet indicative of the steps utilised.

In general the method of dust collecting and sampling is that described in many publications of the United States Public Health reports. The collecting apparatus as shown in an accompanying photograph, chiefly consists of a motor driven rotor type of pump connected with various manometers which permit of calibration in order to record precisely measured quantities of air containing dusts, and lastly an impinger submerged in water or other collecting medium. In practice, measured quantities of air containing dusts from 10 to 50 feet are drawn through the apparatus at the approximate rate of 1 cubic foot per minute.

At the end of the sample collecting period, the fluid containing the dust is carefully diluted in standard proportions and eventually a small portion is placed in a microscopic cell under the microscope and the actual number of dust particles in a minute fraction of the sample is counted. Counting may be carried out either by the light field or dark field method, each having certain advantages and disadvantages. In our own work we invariably use the dark field method as this yields from 5 to 20 times the number of particles visible through the light field method.

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Equipment Used for Collecting of Dust Samples
To Be Followed by Dust Particle Enumeration

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From the dust counts made a number of conclusions may be drawn and now appear:

1. The irregularity and intermittency of much dust work about this plant deprives dust count values of much practical significance in some instances. For example, a dust count made while a workman is dumping a dozen or more bags of tripoli into a hopper may reveal an enormous but temporary dustiness. This same operation may not be repeated for a week. Although some fine dusts may remain suspended in the atmosphere for many hours, it may not be claimed that the dust count reveals or proves a practical dust exposure.
2. In truth, there are no standards for marking, through dust count values, threshold dangers for any given dust. Further, there is no fixed relationship between values obtained respectively through the dark and light field methods.
3. Regardless of the nature of a dust, it is undesirable that workmen be exposed to any extraordinarily high dust concentrations. In certain places in the plant, dusts of somewhat harmless nature are present in excessively high concentrations. Even though these dusts be rated as incapable of bringing about either poisonings or pulmonary fibrosis, no warrant exists for the perpetuation of these high concentrations. Two such locations are now mentioned by way of examples, but these two examples are the chief offenders. Namely, they are lithopone bagging and azo dye finishing and packing.
4. In connection with certain dusts, chiefly in the Chemical Products division, which do not lend themselves to ordinary dust counts, an apparatus was prepared which pumped measured quantities of air through filter papers. The objective was to procure the deposition of colored dusts on these filter papers and thus serve as a measure of the quantity of dust taken up by workers who do not wear respirators. This brief study was casual and the results are far from complete or conclusive. At the end of this section the procedure and results, such as were obtained, are presented.



Stone Dressing. This Operation Involves The Creation of Silica Dust. The Makeshift Protective Equipment Here Shown is Inadequate. Potential Danger Associated with this Operation Depends Upon the Quantity of Silica Dust Produced and the Frequency with Which This Operation is Carried Out. Lead Dust At Times May be Created.

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DUST COUNT RESULTS

Date of Sampling: 11-1-37

Sample #	Millions of dust particles less than 10 microns in size per cubic foot of air	Sampling point
81	40.7	Paint Dept. "B"--mixing floor; filling mixers #12 A and #12 B with #20 dry. Sampling period 15 minutes.
82	20.1	Coal tar plant; dumping asbestos fibre #1551 for production of Tar 206. Sampling period 6 minutes.
83	2,250 (or 2½ billion)	Lithopone Dept.--bagging #2979 dry; sample taken 6 feet from bag-filling chute. Sampling period 4 minutes.
84	181	Black Ash Plant; filling boat from hopper at end of kiln. Dust collected in alcohol (approx. 90% ethyl, 10% methyl)
86	27	Lithopone Dept. 2nd floor general atmosphere 10 minutes after filling hopper for Raymond mill; sampling period 8 minutes; two minutes later hopper filling was resumed
87	2,770 (or 2.77 billion)	Lithopone Dept. 2nd floor. One foot from hopper above Raymond mill while filling with #2979 dry.

All dust particles as counted were below 10 microns in size and usually below 5 microns.

0007-SWP-000030478

DUST COUNT SHEET

Place Mixer 12 A & B Date 11-1-37
 Department or Site "B" Department - Paint
 Exact Operation or Condition Mixing No. 20 dry
 Current and Voltage 110

DUST SAMPLING

Aneroid Reading 758 Mercury Barometer
 Before Test
 Temperature 18° C. During Test 7.6
 Orifice Pressure. Inches 2.7
 Duration of Run: Minutes 15 Time Start 10:59 Time Finish 11:14
 Medium H₂O
 Number in series of tests made at this operation 1 2 3 4 5
 Type of Dust Mag. Silicate
 Remarks on Dust Sampling Quite dusty; paper bags dumped; operator wearing mask

Initials of Sampler W.N.W.

DUST COUNTING

lapsed Hours after Collection 10 Dilution None
 Average No. of Particles in $\frac{1}{2}$ cmm. 625
 Average Number of Particles in Blank 7
 Number of Particles to be Extended 618 Number of Chambers Counted 1
 Estimate of Size of Particles
 Method of Counting: DF Central stop LF
 Value of P H T Theta
 Number of Cu. Ft. of Air in Sample $15 \times 1.062 \times \frac{758}{760} \times \frac{273}{291} = 14.9$
 Dust Particles per Cu. Ft. of Air of Sample $\frac{618 \times 4 \times 250 \times 1000}{14.9 \times 1.02} = 40,700,000 < 10 \text{ mm.}$
 Average of any Several Counts at Same Time
 Remarks on Dust Counting

Initials of Enumerator W.N.W.

Related Information. Calibration of Whipple = 1010 mm.
 $1.01 \times 1.01 \times 1 = 1.02 \text{ cubic mm.}$

0007-SWP-000030479

Air Filter Plates

A convenient method for demonstrating the excessive dust created by certain operations is the simple procedure of filtering the dusty air through standard 5 inch diameter chemical filter paper supported at the end of a 3 inch diameter glass funnel. The suction required to draw the air through the paper is produced by the same apparatus as is used for the collection of dust samples in water. The amount of air filtered is measured by a dry gas meter placed in the suction line.

Several of these filter plates have been made, and the results are discussed below.

Plate I General atmosphere sample in the dry color packing room. 5.8 cubic feet of air were filtered during a sampling period of 12 minutes. Although during this period only chrome yellow pigment was being packed, a definitely visible deposit was obtained on the test filter paper.

Plate II Dry color packing room. Sample taken near mill # 1 while filling a barrel with # D-2268 dry, about 5 feet from barrel. 5 cubic feet of air were drawn through the filter paper during a period of 17 minutes; the deposit obtained on this plate is not significantly greater than that found on Plate I. If this test had been made on the platform directly over the magnetic separator, a much denser deposit would have been found on the test paper.

Most of the dust created by this mill is exhausted through the wall by a propeller fan, causing a general nuisance, and at times producing a high lead exposure for anyone walking along the adjacent platform. (See lead sample # 78)

Plate III Dry color packing room. This plate was not made by the filtering technic described above, but is included in this series as visible evidence of high dust concentrations in the air of the packing room over a period of several hours. The dust settling on 50 square inches of the polished metal cover of the dust sampling apparatus during a period of 2½ hours was carefully removed, placed on a clean filter paper, and spread around as a thin deposit about 3 inches in diameter. The horizontal surface from which this dust was removed was about 15 feet from Mill # 1. The mill had been operating on a chrome green pigment for about one hour prior to the discovery of the dust deposit on the dust sampling apparatus.

Plate IV Azo Dept. 2nd floor. The very heavy deposit on this plate occurred while filtering 2 cubic feet of air over a period of 7 minutes. This test demonstrates the excessive dustiness created by the operation of filling blender # 5 with pigment # CP-579. The filter paper was mounted 3 feet from the enclosure built over the blender opening, but judging from the heavy cloud of dust which eventually filled the entire room, substantially the same deposit would have been obtained 10 or 15 feet from the blender opening.

Plate V Azo Dept. 2nd floor. General atmosphere 5 minutes after filling blender # 5. The sampling period and amount of air filtered were the same as for Plate IV. Only a very light deposit was obtained on this plate, indicating that most of the dust had settled to the floor in a few minutes after being suspended in the air.

ATMOSPHERIC ANALYSES FOR LEAD

Wherever lead is known to be in use, the possibility exists that some may enter the atmosphere in the form of dust or fume or both, depending upon the nature of the operation involved. In this plant, the predominant potential exposures to lead is dust. Under a great variety of circumstances, lead is produced and in the absence of protection it is well known that sufficient lead is present to induce lead poisoning. These known lead work places are not so important in connection with this investigation as the borderline work places or the places unsuspected of harboring lead when in fact lead is present.

With this idea in mind, carefully measured air samples have been collected under appropriate circumstances, later briefly to be mentioned, and the content of these collected samples have been carefully analyzed for lead, using the new method of Harrold, Meak and Holden. A printed copy of the original work on this method is enclosed herewith as a portion of this report. These reprints have been furnished by Dr. Harrold, who has been associated with Dr. McCord during the period that this new method was developed. Applied under proper circumstances, there is no reason to believe that this method is other than precisely accurate down to a small fraction of a milligram of lead.

Prior to the analyses of these lead samples, the method used for collecting the leaded air was primarily that used for collecting air samples for making of dust counts. This method is described in many publications, including "Construction and Use of Impinger Dust Sampling Apparatus", United States Public Health Reports, Vol. 47, No. 12, March 18, 1932. In brief, it may be stated that this method primarily consists of a motor which operates a rotor type of pump which pump is associated with one or more manometers, which when properly calibrated indicate the passage of a known quantity of air per unit of time, such as 1 foot of air per minute. This apparatus appears in a photograph accompanying another section. This equipment has been transported from place to place and samples of leaded air have been collected ordinarily at the rate of one foot per minute. When the concentration of lead was known to be high, the number of cubic feet of air collected for the sample to be

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tested was low. Conversely, when no known lead existed, the volume of the sample was appreciably increased. Using this method, 88% samples have been collected and utilized. These shortly are shown in tabular form. In considering the significance of these results, it is to be remembered that 1.5 milligrams of lead per 10 cubic meters of air is the threshold upon which it may be expected that some lead poisoning might arise among exposed workmen. Thus in a sample yielding the result of 150 milligrams, it is to be recognized that 100 times the threshold of danger point exists. The accumulated data are now shown:

<u>Sample No.</u>	<u>Mg. Lead per 10 cu. meters</u>	<u>Sampling Point</u>
1	1.9	Tin Can Dept., soldering ears.
2	11.3	Tin Can Dept., for automatic seam soldering.
3	0.8	Tin Can Dept., hand soldering
4	5.0	Tin Can Dept., automatic seam soldering
5	0.2	Tin Can Dept., nozzle sweating
6	.33	Calcium Reclaiming Plant—2nd floor—in front of calcium smelter. Cadmium?
7	.25	Calcium Reclaiming Plant—2nd floor—general atmosphere near calcium precipitating tubs.
8	1.5	Front of tan bark furnaces
9	2.7	Tan bark furnace room
10	15.8	Tan bark furnace room near hopper filling
11	2.2	Lead buckle casting machine
13	324	Within lead stack while drawing
14	15.7	Dumping corroded lead into hopper
15	6.1	Tan bark burner room; lead ash cooling
16	15.4	Litharge grinder—mechanical feeder leak
17	1.4	White lead office
18	218	Filling drums with litharge
20	4.6	White lead grinding—not operating
21	2.5	White lead filter bag room
22	265	White lead grinding—operating—"very dusty".
23	142	Loading quick process drum
24	264	Drawing litharge from furnace; lower doors open
25	96	Same as #24; lower door closed
26	220	Between operators shoveling metallic lead into furnace
28	21.8	Dry color packing—#12082 (orange)
29	202	Dry color packing—#11077 L (green)
		On platform above belt conveyor
30	470	Dry color packing—#12007 (yellow)
32	27.2	Paint dept. "B"—adding #20 dry to mixer #8 A
33	164	Paint dept. "B"—loading hopper for primer mill (using pigment containing 35% lead—#4120)
34	145	Paint dept. "B"—loading small batch RxCX 6593 (using #11077 green)
35	5.4	Paint dept. "B"—general atmosphere
37	33.8	Quick process—water sprinkling cylinders 38 & 39
38	98.5	Quick process—on runway over cylinder #47 during pounding process



Dutch Process White Lead Manufacture.
Emptying of Containers of White Lead
from Tanker Stacks. Lead Dust Inevi-
tably Present. Possibility of Exten-
sive Quantities of Carbon Dioxide.

<u>Sample No.</u>	<u>Wg. Lead</u> <u>per 10 cu. meters</u>	<u>Sampling Point</u>
39	25.5	White lead laboratory—sifting litharge for "gram weight test"
43	2.1	Beta Naphthol dept.—near chipper
44	2.2	Azo Dye—loading new large blender with CP 594, lot 45
45	5.1	Azo Dye—filling drums—same material as in #44
47	24.5	Quick process—general morning atmosphere—cylinders opened during last minute of run
48	28	White lead packing
49	280	Blowing "blue lead", outside hopper room
50	26	Packing red lead in drums
51	6.5	Red lead furnace room—general atmosphere during blue lead blowing in adjacent room
52	9.5	Pigment products—outer office—window open to East
53	5.1	White lead department—tally desk—"pulpers"
54	2.7	White lead department—wet screening—pulpers
55	17.7	Red lead filter bag room
56	4.6	Tin Can Department—terne plate splitter
62	1.4	Outdoor sample at east side of lithopone building, 15 feet from the wall
63	1.4	Lithopone plant—1st floor—general atmosphere sample—25 feet from Raymond mill
64	2.3	Lithopone plant—2nd floor—general atmosphere during filling of Raymond mill hopper. Sample taken 25 feet from hopper
65	21.7	Lithopone plant—1st floor near bagging scale
66	2.8	Lithopone plant—filling grinder hopper, northwest corner, 3rd floor
68	4.0	Black ash plant—grinding ore and coal
69	3.8	Bag salvage, baling bags
70	4.8	Lead departments locker room adjoining white lead plant—4:10 to 4:30 P.M.
72	2.6	Superintendent's office, White lead building.
73	2.0	Outdoor sample, between buildings 220 (White Lead) and 265. Wind blowing from white lead stacks toward sampling point.
74	.75	Outdoor sample northeast of white lead building, 25 feet from wall of Stain House (H Department).
75	51.6	Dry Color Factory, 2nd floor, filling No. 9 blender with No. 11024 dry
76	2.5	Dry Color Factory, 2nd floor, filling No. 7 blender with No. 11215 dry
77	107	Dry Color Factory—filling blender No. 4 with No. 12074 dry
78	8.7	Dry Color Factory—outdoor sample on platform 12 feet from wall fan exhausting mill No. 1 grinding No. 11024 dry
79	207	Dry Color Factory—packing floor. Filling drums with No. 11215 dry from blender #7. Exhaust not operating.
80	18.5	Same as No. 79, exhaust operating
89	1.6	Dry Color Factory—3rd floor (mixing) General atmosphere.
90	170	Dry Color Factory—mixing floor. Loading mixing tub No. 4 with white lead (1100 lbs.)

<u>Sample No.</u>	<u>Mg. Lead per 10 cu. meters</u>	<u>Sampling Point</u>
40	100	Lithopone Department--bagging
41	29	Lithopone Department--loading grinder hopper

Analysis of Blanks on Water Used for Lead Samples

<u>Flask No.</u>	<u>Total mg. Pb in 250 ml. H₂O</u>	<u>Equivalent mg. Pb/10 cu. m. air assuming 15 minute sampling period</u>
12	.008	.19
19	.01	.25
51	.01	.25
42	.006	.14
46	.008	.19

Double distilled water stored in pyrex bottle
(samples 47 to 58)

57	.006	.14
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Triple distilled water stored in soft glass bottle
(samples 62 to 90)

67	.006	.14
71	.006	.14
91	.01	.25



White Lead Filling. Dusty Operation
Calling for Worker Protection and
Cleanliness of Premises

Comment on Air Analyses for Lead

1) The saving grace in this plant with respect to protection against lead is the faithful wearing of respirators. Many plants complain that it is well nigh impossible to enforce the wearing of respirators. In this plant, to the contrary, on no occasion have these investigators observed men regularly employed in known lead exposures working without respirators. If this were not so, it is believable that at all times there would be large numbers of lead poisoning cases under observation among the total group of workmen. In short, this statement means that very obviously lead in many varieties is present in many places throughout this plant in quantities constituting a practical threat to the unprotected workman.

2) Not only is lead present in the atmosphere in places where it is expectable, but as a result of years of tracking about, almost the entire plant may be shown to contain some lead. For example, in the office of the Superintendent of the Pigment Products Department, it is possible to show that during the course of every day work, these officers of the company perhaps breathe as much as 2-6 milligrams of lead. As a result, it is known that one or more of the managerial group in this department present some evidence of lead absorption. It is the intent of this comment to maintain that on a qualitative basis lead exposure is universal to this plant and that lead poisoning conceivably might arise in any work place outside of such departments as office, medical, etc.

3) In going over the results above tabulated, it may be observed that certain of the results are amazingly high, in comparison with the threshold of beginning danger. In addition to providing an immediate local potential exposure, it is possible that this lead may be carried out in air streams into other departments making no use of lead and conceivably at least into different buildings. This section is written up at a time when complete returns from all analyses are not yet in, but even so there is the suggestion that air-borne lead may play some part in the results obtained in lead analyses.

4) It is noteworthy that harmful quantities of lead in the form of fume may be demonstrated in the Tin Can Plant, chiefly associated with

automatic soldering operations. The difficulty that exists leading to this undesirable situation is not enough air is being pulled through the exhaust system. Moreover, as we have pointed out in special discussions, the hoods over the operations are in many instances located too high to be truly effective.

5) Another section of this report is devoted to blood findings, constituting some evidence of lead absorption. A fair correlation exists between these air analyses for lead and the otherwise reported blood analyses. This correlation cannot be perfect or complete, owing to the fact that large numbers of workers wear respirators, thus upsetting the blood pictures that would arise in the absence of this laudable protection.

6) The widespread and high quantities of lead give rise to the thought that more attention must be paid to the fitting and servicing of respirators in this plant. By and large, there are some 75-100 men in this plant who are near the threshold of lead poisoning. An acute respiratory disease, alcoholic bout, a gastro-intestinal upset might readily precipitate disabling lead poisoning in any one of these workmen. It is highly desirable that exposures be kept as low as possible through the use of not only respirators but respirators that adequately fit and which are adequately cleaned and otherwise serviced at frequent intervals. Moreover, it seems necessary to recommend the more extensive use of respirators than has existed heretofore. By this is meant that in every department where most of the workers are now faithfully wearing respirators, there are, in addition, probably three or four workmen who feel themselves insufficiently exposed to warrant respirator wearing. Evidence seems to be to the contrary.

7) The Legal section of this report found in Volume I discusses our finding of a distribution of lead in many non-lead using buildings throughout the plant. For example, it may be noted that the attendant in the small building manufacturing carbon dioxide gas which is just outside the Quick Process building is showing some trivial signs of lead absorption. If in fact he has lead absorption, this probably is due to lead in the general atmosphere swept in under his boilers but originating in the Quick Process room or some

other nearby lead operation. To avoid repetition, additional comment on this subject is avoided, but reference is made to the Legal section for a continuation of this matter.

8) In general, it is the intent of this discussion to emphasize that lead in high quantities is present almost everywhere in the atmosphere in and out of buildings connected with this plant. The situation is so serious as to warrant the concern both of the local and general office management.

A PRACTICAL METHOD FOR THE RAPID DETERMINATION OF LEAD WHEN FOUND IN THE ATMOSPHERE*

G. C. HARROLD, S. F. MEEK AND F. R. HOLDEN

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THE determination of lead in small amounts found in air has been carried out in the past by some modification of Fairhall's chromate method (1, 2). These modifications include those using the S-diphenylcarbazide developed by Cazeneuve (3) as an indicator for hexavalent chromium. Kehoe (4, 5) and others found this method inferior to a spectroscopic determination (6, 7) especially when used for biological material. Electrolytic methods have also been proposed (8) as have various colorimetric procedures (9, 10). Recently a number of investigators (11, 12, 13, 14, 15) have developed modifications of Fischer (16) and Leopoldi's (17) dithizone method for the quantitative determination of lead for use in various types of investigations. We have for some time used a modification of this method for the determination of lead in air.

Inasmuch as we know of no other method which permits one to collect and analyze so many samples of air that may be lead-contaminated, we describe here the sampling and analyzing procedure in the hope of contributing to the development of rapid and accurate methods for the determination of toxic substances in the field of industrial hygiene. Since it is felt

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that too many of the methods require equipment not available to the average worker in industrial sanitation, we propose in this method to limit the use of expensive or special equipment.

The details of the sampling apparatus can be obtained from papers written by Greenburg *et al.* (18) and Bloomfield (19). Ordinary items of Pyrex laboratory glassware will be the only other items of equipment necessary.

Sampling procedure for lead.—Using a modified Greenburg-Smith impinger and air sampler, one collects ordinary lead dust composed of lead oxides, etc., in 250 cc. of lead-free distilled water. For some lead compounds and lead fumes where it is best to collect the sample in a dilute nitric acid solution, one uses 10 cc. of concentrated nitric acid (C.P., Sp. G. 1.42-1.43) in the 250 cc. of distilled water. Inasmuch as we, for the sake of convenience and accuracy, in evaporation, ordinarily use 500 cc. Pyrex wide-mouth Erlenmeyer flasks with 250 cc. of distilled water, the quantities of acid and subsequent reagents are based on that procedure. Should one use other collection bottles, containing less distilled water (75-150 cc.) as in some types recently described (20), modified reagent amounts should be used.

The sampling time for quantities of lead which will approximate 1.5 or less mg. per 10 cu. m. of air should be from 30 to 40 minutes. In areas where the amounts of lead are greater than 1.5 mg. per 10 cu. m. of air, the time of sampling should be reduced according to the concentration as the amounts of lead analyzed by this method are in the neighborhood of thousandths of a milligram, and should not exceed 0.1 mg.

The sample is collected either with the 10 cc. of concentrated nitric acid added or in pure distilled water. If collected in pure distilled water, add the same quantity (exactly 10 cc.) concentrated nitric acid after collection. The sample is boiled in the original sampling flask until the quantity is slightly less than 90 cc. After cooling, place in 100 cc. volumetric flasks. Wash the sampling flask with two 5 cc. portions of distilled water and add this wash water to the volumetric flask. Then dilute to the mark with distilled water. Remove an aliquot portion of 5 cc. which quantity will contain approximately 0.5 cc. of concentrated nitric acid. It is important to add exactly 10 cc. of nitric acid and no more. Too little acid will cause destruction of the dithizone reagent. Too great an amount will lower the pH below 9.7 which is the alkalinity to which the lead extractive solution has been adjusted. This has been shown to be the optimum pH by Clifford and Wichmann (21). The reagents have been adjusted to care for all commonly interfering metallic ions, but this will not be true unless the described conditions are followed precisely.

CHEMICAL ANALYSIS

Preparation of Solutions.—Prepare (1) a 5 per cent ammonium citrate solution from citric acid by the addition of ammonium hydroxide until just alkaline to litmus paper.

(2) 10 per cent solution of potassium cyanide.

(3) *Lead extractive solution.*—Mix 15 cc. of 10 per cent potassium cyanide solution and 20 cc. of ammonium citrate solution with 53 cc. of concentrated ammonium hydroxide (Sp. G. 0.9), and then add 450 cc. of water. (This solution is used to neutralize the excess nitric acid, and provide the proper pH of from 9.5-10.)

(4) *Dithizone extractive solution.*—5 cc. potassium cyanide 10 per cent, 15 cc. concentrated ammonium hydroxide to 500 cc. of water.

(5) *Dithizone solution.*—25 mg. dithizone per liter of pure chloroform.

Standard lead solution.—1.598 gr. lead nitrate (recrystallized) in 1000 cc. of 0.1 per cent nitric acid solution.

1 cc. of this solution = .001 gr. lead = 1 mg. lead.

10 cc. of above is diluted to 1000 cc. Whence 1 cc. of the dilution solution = .01 mg. lead.

All reagents should be of the highest purity obtainable.

Detailed procedure.—15 cc. of the lead extractive solution is placed in each of the Squibb separatory funnels. Exactly 5 cc. of the unknown sample contained in the 100 cc. volumetric flask is added. Then add the dithizone solution from a burette in 0.3 cc. portions, shaking the separatory funnel after each addition until a slight purple tinge is noticed in the chloroform layer. The dithizone in

chloroform layer turns a bright cherry red when shaken with lead-containing solutions. After all the lead has been extracted, any excess dithizone changes the color from cherry red to purple. Then add pure chloroform from a burette in sufficient amount so that the total of dithizone solution and chloroform are equal to exactly 10 cc. Shake again for not over 10 seconds (14). Allow the layers to separate. Drain the chloroform layer into another Squibb separatory funnel containing 20 cc. of the dithizone extractive solution. The chloroform layer is shaken with the 20 cc. of dithizone extractive solution and treated with a second portion of 20 cc. of dithizone extractive solution if too great an excess of dithizone has been added. The color of the resulting chloroform solution is a bright, clear cherry red. It has been shown (14) that two extractions are usually sufficient.

After the chloroform layer has settled, place the stopper in the separatory funnel. The drop at the top of the aqueous layer is brought to the bottom by repeating the tapping and shaking with a slight rocking motion, and one draws the chloroform layer into a test tube or comparator tube, first wiping the inside of the stem of the separatory funnel with a cotton swab or pipe cleaner to remove moisture. These test tubes or comparator tubes are then stoppered and kept tightly closed.

Three (3) standard solutions containing 0.005 mg., 0.01 and 0.015 mg. of lead respectively are made at the same time that the unknowns are prepared for analysis. These standards are made as follows:

For the 0.005 milligram standard.—5 cc. of the dilute lead nitrate standard is added to 40 cc. of water and 5 cc. of concentrated nitric acid added; then, after this solution has been thoroughly mixed, a 5 cc. portion is taken and treated exactly as described for the unknowns.

Use proportionately larger amounts of the dilute lead nitrate standard for the other standards.

To make up standards containing 0.045 mg. or more of lead, use the concentrated lead standard containing 1.0 mg. lead per cc. Thus, for making an 0.07 mg. standard, add 0.7 cc. of the concentrated lead standard to 5 cc. of nitric acid and dilute to 50 cc. with distilled water. Take 5 cc. of this quantity for analysis. The resultant pH is 9.5-10 under conditions as stated.

These standards, after the lead extraction and the removal of excess dithizone, are placed in tubes similar to those used for the unknown samples. By placing the unknown sample between the two standards that are nearest the unknown in shade and holding up in front of a standard source of white light, one is able to determine the lead content within 0.001 mg. This does not hold when more than 0.1 mg. of lead is present in the sample taken for analysis. Best results are obtained when the portion taken for analysis contains less than 0.04 mg. of lead.

DISCUSSION

These lead standards, on which analyses are based, must be made fresh every day. We have found that there is a slight but measurable fading of color on exposure to light. How-

ever, this fading is negligible during the course of a working day, especially if the standards are protected from light during the time not in actual use. While we found some samples which did not fade, the only way to be certain of accurate results is to prepare the standard each day. We have further found that if pure reagents and Pyrex glassware funnels and comparing tubes are used no blank determination is necessary. It is, however, advisable to test all solutions and glassware for lead. Should any materials or solutions prove to have enough lead to give a pronounced red color when 1 cc. of the dithizone reagent is used, the entire quantity of this material should be treated to remove lead. All glassware should be rinsed with dilute nitric acid and tested with the dithizone reagent before use. We have found that, due to distinguishability of the shades produced at these concentrations, observers are able to state the concentrations of the unknown solutions to within 0.001 mg. Furthermore, we have found that solutions compared in this way when analyzed by means of the colorimeter agreed in all cases within 0.001 mg.

Due to evaporation of chloroform when in the open colorimeter cup, we have found that this method is as accurate as that in which the colorimeter is used unless special, time-consuming and laborious precautions are taken. It is recommended that the unknown being compared to a standard be referred to a standard which is stronger than itself. A great number of tests checked with a colorimeter have shown that the comparisons are not as accurate when

the unknown is compared to a standard sensibly inferior to it in strength as when the unknown is approximately equal to or less concentrated than the standard.

It is obvious that, when one is collecting samples that may have a lead content greater than those for which the foregoing has been designed, one may use a smaller portion of the total sample, provided one adds sufficient nitric acid to bring the solution up to the proper acidity. It is, however, recommended in the analysis of air that, when the operator collecting the sample has reason to suspect larger quantities of lead in the air, he should reduce the sample from 30 or 40 cu. ft. to 15 cu. ft. or less.

MODIFICATION TO INSURE GREATER ACCURACY

Clifford and Wichmann (21) have developed a further refinement of the general method of analysis of lead by dithizone reagent. This modification is what they call a "mixed color" method.

A slight change in the previously discussed procedure based on their work will enable one to determine lead amounts with increased accuracy, and under certain conditions more expeditiously.

The only change in reagent or apparatus is the making up of additional solutions of dithizone.

General.—Dissolve respectively 4 mg. and 10 mg. of dithizone in 1 liter of chloroform (store in brown bottles). All the former discussion is relevant until one adds the dithizone when the following changes in procedure become necessary.

In place of adding dithizone to the

lead extractive solution containing the lead, until a slight purple tinge appears, one adds a known volume of known concentration of the dithizone reagent. These concentrations are so adjusted as to give colors ranging from green through blue-green to purple shades, and finally a cherry red.

We have found it advantageous to use small known amounts of the weakest dithizone reagent for the unknown sample and the same solution for the standards nearest the unknown in lead concentration.

Then by adding a definite volume of the stronger solution, the unknowns having larger lead content may be determined. Other standards will then be made up containing larger known quantities of lead and the dithizone will be added in two portions, one, the known amount of weak dithizone as added to the weak standards, and the second portion of stronger dithizone as added to the unknown sample.

By following this method of adding the dithizone reagent, an unknown containing up to 0.2 mg. of lead may be accurately determined. Most routine work demands no more than four to six standards.

Detailed procedure.—Collect sample as previously mentioned. Add 5 cc. of the unknown sample contained in 100 cc. volumetric flasks to 15 cc. of lead extractive solution. Shake thoroughly and add 5 cc. of the dithizone solution containing 4 mg. per L. Shake vigorously. This amount and concentration is very sensitive for from 0 to 0.005 mg. of lead. If the dithizone solution turns a cherry red indicating that the unknown contains larger amounts of lead, one then adds 5 cc.

of the 10 mg. per L. dithizone reagent which will be sensitive with the dithizone already added, up to about 0.015 mg. of lead. Should the color still be cherry red, it is recommended that 5 cc. of the 25 mg. per L. solution be used. This will increase the lead which can be determined up to about 0.05 mg. If still larger quantities of lead are present, one may add the successive increments of the 25 mg. per L. dithizone up to about 25 cc. when the sensitive limit will be reached. This procedure will allow a top limit of about 0.25 mg. to be determined. It is recommended, however, that a smaller aliquot portion of the total lead sample be used, should one have over 0.15 mg. in the sample. Draw off the chloroform layer containing the lead dithizone complex into the comparator tubes and compare with the standards. The greatest sensitivity is found when using the deeper purple shades.

The standard lead solutions made as previously described are the same volume as the unknown sample. They must be treated exactly as the unknown sample. It is cautioned that the analyst should never compare unknown samples which approach to near cherry-red color. It is further recommended that when greater accuracy is desired the number of standards be increased so that the range in lead content is never more than 0.002 mg. between any two standards.

Discussion.—This procedure has, in addition to a greater accuracy, the advantage that larger samples can be analysed with no sacrifice in accuracy. Using this modification with an aliquot of 1 cc. of the 100 cc. sample, it would be possible to analyze air accurately

containing up to 700 mg. of lead per 10 cu. m. of air. Using smaller aliquots, the limits could be raised much higher, though the need for such a procedure can not be foreseen at this time. Conversely it should be possible to analyze air containing even less than 0.001 mg. of lead in 10 cu. m. of air.

excellent discussion of the various modifications of the dithizone analysis for lead.

SURVEY OF ADEQUACY OF THE METHOD

The following analytical data picture the accuracy of the procedure under various conditions.

The error involved in this method

TABLE 1

KNOWN LEAD ADDED	AMOUNT FOUND USING COLORIMETER		MAXIMUM ERROR	AMOUNT FOUND USING COMPARISON AS IN METHOD GIVEN (THREE OBSERVATIONS)		
	#1	#2		mg.	mg.	mg.
0.005	0.0033	0.0048	+8.0 (#1)	0.005	0.005	0.005
0.008	0.0078	0.0082	+2.5	0.008	0.007	0.008
0.01	0.0104	0.0104	+4.0	0.011	0.009	0.009
0.015	0.0158	0.0148	+5.2	0.015	0.014	0.015
0.02	0.0202	0.0209	+4.5	0.021	0.02	0.02
0.025	0.0261	0.026	+4.4	0.026	0.026	0.024
0.03	0.0314	0.0308	+4.7	0.031	0.030	0.030
0.035	0.0346	0.0341	-2.6	0.033	0.035	0.034
0.04	0.0411	0.0406	+2.8	0.04	0.041	0.038
0.05	0.0489	0.0506	-2.2	0.048	0.052	0.052
0.08	0.0782	0.079	-2.3	0.081	0.084	0.082
0.1	0.1024	0.1031	+2.4	0.101	0.103	0.098
0.15	0.1528	0.1536	+2.4	0.153	0.148	0.149

TABLE 2

LEAD ADDED	RESULTS WHEN ALL DITHIZONE IS EXTRACTED— Pb FOUND (TWO OBSERVATIONS)			RESULTS WHEN MODIFIED METHOD IS USED— Pb FOUND		
	mg.	mg.	Av.	mg.	mg.	Av.
0.005	0.005	0.004	0.0045	0.005	0.005	0.005
0.008	0.007	0.008	0.0075	0.008	0.008	0.008
0.01	0.009	0.011	0.01	0.011	0.01	0.0105
0.025	0.024	0.024	0.024	0.025	0.025	0.025
0.04	0.042	0.039	0.0405	0.040	0.040	0.040
0.05	0.051	0.05	0.0505	0.050	0.051	0.0505
0.08	0.082	0.077	0.0795	0.081	0.081	0.081
0.1	0.104	0.097	0.1005	0.100	0.100	0.100

Should photometric apparatus be available, this procedure can be made more rapid than the details as outlined. Clifford and Wichmann (21) give a complete description of the technic to be used in this case as well as an

compares very favorably with those results obtained with the colorimeter. Greater practice in distinguishing shades of color on the analyst's part leads to closer approximations to the actual lead concentration.

Results obtained using the modified method compared to results obtained by the method when all excess dithizone is removed are shown in table 2. These figures indicate that an analyst familiar with the variations in tints produced by addition of excesses of dithizone can obtain results accurate to less than 3 per cent of the lead present. The error is of course greater when very small quantities are analyzed. For this reason, the analyst should so choose his sample aliquot that it contains between 0.005 and 0.15 mg. of lead. This is not difficult after a short familiarity with the method. The speed of the method is not appreciably affected inasmuch as the extractions with dithizone extractive solution are eliminated.

INTERFERENCE OF METAL IONS

The only interference which occurs with diphenylthiocarbazon in the solutions used is that due to stannous tin, bismuth and thallium. We have neglected thallium because of the small amounts of this material used in industry. Bismuth and tin do not interfere due to the excess ammonium hydroxide and ammonium citrate which remove these metals while in combination with dithizone. It is not known how completely this procedure removes the interferences. It may be that compensatory errors cause the removal to appear complete. However, it has been observed that, in the analysis of air containing solder particles with a composition of approximately 50 per cent tin and 50 per cent lead, no appreciable error is evident.

The following experiment was made. Air samples containing the unknown material were divided into two equal

parts after the addition of nitric acid. One portion was treated as suggested by Clifford and Wichmann (21) for removal of tin and the lead then determined by the "mixed color" method. The other portion was treated by the "one color" method described in this article. No appreciable error was evident. The results are shown in table 3.

TABLE 3

	LEAD FOUND (LEAD AND TIN)	LEAD FOUND (TIN REMOVED)
	mg.	mg.
1	0.023	0.022
2	0.02	0.022
3	0.04	0.040
4	0.012	0.011

TABLE 4

LEAD FOUND IN PRESENCE OF INTERFERING ELEMENTS

LEAD ADDED	BISMUTH ADDED	STANNOUS TIN ADDED	LEAD RECOVERED
mg.	mg.	mg.	mg.
0.02	0.01		0.021
0.02		0.01	0.019
0.04	0.01		0.041
0.04		0.01	0.04
0.02	0.01	0.01	0.02
0.04	0.01	0.01	0.041

It may prove advantageous if a problem involving bismuth and lead should arise to remove the bismuth by Willoughby's procedure (22), although it appears that reasonable results for routine work can be obtained without such preliminary removal if quantities for analysis are above 0.01 mg. This stand is taken in view of the errors of air sampling but cannot be condoned should extreme accuracy be desired.

These results shown in table 4 were obtained by using the method as given in the general procedure, using the dithizone extractive solution to remove excess dithizone. In actual practice, where it is used with lead, the interference is found to be negligible even when the shortened routine method is used.

Comparison of three methods.—It was found that, when using a modified indirect chromate method, results were invariably higher than they should have been. As used by us, the excess of standard hexavalent chromium was determined colorimetrically using diphenylcarbazide as the indicator, after lead chromate had been separated by filtration.

Our results seem consistent with the spectroscopic results obtained by another laboratory, and about the same order of accuracy as other results previously presented.

Discussion of error in air analysis.—The accuracy of this method when a 0.01 mg. sample or more is taken for analysis is certainly greater than needed when the errors of sampling technic are considered. Inasmuch as there is no point in having a method much more sensitive than the whole process of collection of sample and analysis, it is felt that, because of the speed in analysis and the smaller sampling time that is directly related to the smaller quantities of lead which can be accurately analyzed, this method is much superior to the methods previously used in lead analysis of air samples.

It is further to be noted that no blank has been found necessary because the same solutions and amounts of chemicals are used in making up the

standards that are used in the analysis of the unknown sample. We have used the method for other determinations than air analysis and, in such cases, it is of course necessary to determine an accurate blank. This, however, we find in most cases to be 0.001 mg. or less. This is not true for various organic materials requiring digestions and other manipulations.

In conclusion, it should be explained that the value of this procedure is felt to lie in the rapid sampling and analysis of lead in air to the end that control of industrial hazards may be accomplished. Much difficulty in studying complex industrial problems arises be-

TABLE 5
ACTUAL SAMPLES WITH INTERFERING SUBSTANCES PRESENT

RESULTS OF CHROMATE METHOD, LEAD	RESULTS OF DITHIZONE METHOD, LEAD	SPECTROSCOPIC ANALYSIS, LEAD
mg.	mg.	mg.
0.025	0.017	0.0162
0.035	0.024	0.0245
0.032	0.018	0.0161
0.034	0.021	0.0227

cause not enough determinations can be made in the time allotted for such study.

SUMMARY

We have presented a means of collecting and analyzing lead in any form using a minimum of expensive equipment. No colorimeter need be used if this procedure is followed, and the only special equipment needed is the air sampler and impinger. It is recognized that by making blank determinations Pyrex separatory funnels and high purity chemicals are not required.

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BLOOD EXAMINATIONS
OF WORKERS PRESUMABLY EXPOSED TO LEAD

In the desire to protect workers against the action of lead, it would be most valuable to have available some test which would serve as an indication of the intake of lead at a time prior to any clinical manifestations of lead poisoning or any discomfort or impairment on the part of the worker. Since lead poisoning is an accumulative disease, it is apparent that always there is a period during which lead is being taken into the body in the absence of any readily demonstrable ill effects.

A test of this character does exist and apparently yields results of high fidelity. While not utterly free from possibility of error, this test when applied to groups of workmen exposed to lead or who may be exposed to lead will ordinarily yield findings marking those persons who are absorbing lead and who are being affected by lead, but are not in a zone attracting attention because of discomfort, disability, weakness or medical signs.

This test is called the basophilic aggregation test, the full nature of which is set forth in an accompanying printed bulletin. In brief, this test is based upon the proved fact that whenever lead is being absorbed into the body, its action is to stimulate the appearance in the blood stream of large numbers of immature red blood cells. These immature red cells possess certain chemical constituents that separate them from ordinary red blood cells found in all blood in large numbers. Among normal persons, these immature red cells are present only in trivial numbers, usually in such range as .4% or .8%. A few normal persons may show percentages as high as 1.5 and any figure below 2% may not be regarded with concern. When, on the other hand, percentages exceed 2, in persons exposed to lead who are otherwise normal, the strong inference may be drawn that lead absorption is taking place.

A fair number of other conditions and other materials may give rise to positive results from this test. Persons with any anemia, and particu-

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Lead Chromate Operation. The Extent of Exposure
In Some Measure Depends Upon the Grinding Up and
Trackage of Material Allowed to Accumulate on Floors.

larly pernicious anemia are prone to have high percentages of immature cells. It is believed that the results of benzol, toluol and similar chemicals may occasion a positive test. It has been reported that in silicosis this test is positive, but this awaits real proof through additional work.

All in all, this test, as described in the printed material, furnishes a fair index of those work areas in this plant where lead is being manipulated or at least where lead in some form or other is reaching workmen.

In this plant, 1057 tests have been carried out. Large numbers of these tests were carried out in non-lead using areas for control purposes. In certain instances, series of tests were carried out because of the suspicion that although lead was not manipulated therein, lead was being transported through air currents, trackage, or otherwise. The distribution of the total number is as follows: Mechanical 147, Lithopone 127, Chemical Products Beta 29, Chemical Products 71, Safety 28, Dry Color 96, Receiving and Stores 57, White Lead 41, "C" Department, 4, "D" Department 5, Lacquer 31, General Office (controls) 14, Power Department 2, Service Department 2, Azo Dye 1, Employment Department (control) 1, Red Lead 18, Quick Process White Lead 27, White Lead Stacks 30, Chemical Products Laboratory 19, Tobias Department 15, "F" Department 8, "H" Department 16, Varnish 16, Fuchsine 20, Coal Tar 25, 104th St. Warehouse 15, "B" Department 22, Tin Can Plant 165, Allied Research 1, "A" Department 7, Acetanilid 5.

From the entire list of examinees, there are here presented a listing by departments of those persons whose B.A. tests are in excess of 2. Also for purposes of comparison, an unselected list of thirty-five controls are here shown to indicate the definitely lower range for those persons unexposed to lead.

<u>Tin Can Department</u>	<u>Name</u>	<u>Badge No.</u>	<u>Occupation</u>	<u>B.A.</u>
		3065	Packer	2.1
	REDACTED	3061	Tin splitter	2.4
		3063	Solderer	3.1

<u>"B" Department</u>	<u>Name</u>	<u>Badge No.</u>	<u>Occupation</u>	<u>B.I.</u>
		42	Mixer	2.5
	REDACTED	57	Mixer	3.0
<u>Coal Tar</u>		642	Operator	2.7
		676	Millman	2.1
<u>Fuchsine</u>		1631	Manufacturer	3.0
<u>Varnish</u>		338	?	2.4
		384	Cooker	2.4
<u>"H" Department</u>				
<u>"F" Department</u>		231	Mixing	2.2
<u>White Lead Stacks</u>		861	Dryer	4.0
		864	Setting	2.0
		873	Setter	3.1
		874	Scaleman	2.1
		894	Drawing	3.6
		852	Drawer	3.5
<u>Quick Process White Lead</u>		768	Washing	2.9
		772	Fireman	3.9
		779	Fireman	2.1
		786	Washer	2.4
		793	Blowing lead	2.9
		799	?	2.1
		684	Pounder	3.0
		758	Sprinkler	2.4
<u>Red Lead</u>		676	Millman	2.1
		694	Assistant	
			Foreman	2.1
		708	Fireman	2.9
		709	Fireman	2.6
		723	Assistant	
			Foreman	2.1
		722	Fireman	4.0
		855	Laborer	2.1
<u>Chemical Products</u>		1338	Neutralizer	2.3
<u>Beta</u>		1391	Filling	2.3
		1407	Pressman	2.4
<u>Lacquer</u>		2503	Millman	2.0
<u>White Lead Dept.</u>		802	Pulper	
			Operator	2.5
		809	Laborer	2.7
		822	Filling and shipping	2.0
		Mo.	Chemist	2.6
		Mo.	Sup't	3.4
		826	Laborer	2.3
		836	Laborer	2.3
		Mo.	Chemist	2.2
		840	Millwright	2.2

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Receiving and
Stores

Name

Badge No. Occupation

R.A.

REDACTED

2188	Coalman	2.4
2198	Trucking	2.0
2202	?	2.6
2131	Trucking	2.1

Dry Color

2050	Pulper	2.2
1999	Pressman	2.3
2011	Press	
	Supervisor	2.0
1962	Millman	2.2
1964	Striker	2.1
1981	Labor	2.4
1982	Pressman	4.2

Chemical Products

1435	Striker	2.5
1451	Cooper	2.1
1460	Blending	2.3
1479	Janitor	4.2
1491	Janitor	2.1
1496	Acid Blower	2.3

Lithopone

1835	Laborer	2.3
1811	Laborer	2.6
1823	Laborer	2.0
1710	Foreman	2.3
1719	Oiler	2.9
1728	Packer	2.1
1742	Dryer	2.0
1758	Millman	2.0
1776	Laborer	2.1
1782	Laborer	2.6

Mechanical

2857	Blacksmith	2.1
2891	Electrician	2.3

Controls

Mo.	Stenographer	0.5
"	"	0.8
"	Clerk	0.7
"	Stenographer	1.2
"	Secretary	0.6
"	"	1.0
"	Sales	0.8
"	Clerk	0.5
"	Secretary	0.6
"	Buyer	0.3
"	Sales	0.7
"	Stenographer	0.8
"	Sales	0.5
"	Clerk	1.0
"	Chemist	
"	(Lith.)	0.5
"	"	0.4
"	"	0.7
"	Clerk	0.9
"	Chemist	
"	(Lith.)	0.5
"	"	0.5
2354	Engineer	0.7
2374	Fireman	0.5
Monthly	Clerk	0.4
1429	C.P. Lab.	1.2
1416	"	0.9
1439	"	0.7

<u>Controls (con't)</u>	<u>Name</u>	<u>Badge No.</u>	<u>Occupation</u>	<u>B.A.</u>
		1455	C. P. Lab	1.3
		1464	"	0.7
	REDACTED	1480	"	0.6
		1497	"	0.6
		Mo.	"	0.7
		"	"	0.6
		"	"	0.4
		"	"	0.9
		"	"	0.5

From the above listing of positive tests, it may not be maintained that these persons are suffering from lead poisoning. It is maintained that the majority of these persons are absorbing some lead or some other chemical provocative of this test and that in the event of the appearance of actual lead poisoning cases, such probably would arise in persons on this list, at least during the next few weeks or months.

From this type of investigative procedure, it seems possible to draw a number of casual conclusions, as follows:

1) Those persons habitually exposed to lead and who habitually wear respirators appear to be less frequently involved than other classes of persons who only irregularly but frequently enter lead using areas. These persons apparently believe that because they are exposed only for short periods, such as an hour or two per day, they are unlikely to acquire lead poisoning. It is noteworthy in this phase of the examination that chemists, foremen, office workers in lead using departments are by no means free from the possibility of lead absorption. In fact, during the period of this investigation one chemist in a lead using department quit because of his own awareness that he was suffering from mild lead poisoning.

2) The results from this phase of the investigation, which inescapably is linked up with other procedures yielding the same findings, indicate that lead is almost universal in its distribution in the atmosphere of this plant. For example, in the offices connected with the Pigment Manufacturing Department, at least as much lead is present in the atmosphere as is necessary to produce lead poisoning and at least one person there shows so highly positive a B. A. test as to make actual lead poisoning a reasonable expectancy. Other areas have yielded

similar results.

3) Owing to the fact that some workers have been transferred for one reason or another, such as from the abandonment of the Insecticide Plant, some positive B.A.'s have been found in areas where lead is not known to be in use. At this time, it is not precisely known how long a person will retain a high percentage of B.A.'s after having once developed this deviation from the normal blood picture. On this account, it is possible that a person who may have worked in the Insecticide Plant, 15 months ago, may harbor abnormal numbers of immature cells even at this very time.

4) Some few workers who faithfully wear respirators throughout their periods of exposure to lead no less present high B. A. findings. Naturally, the question arises as to how this may come about. Several answers are adequate and amply explain the observations made. By no means do all respirators well fit the face of the workmen and completely occlude the entry of lead dust or fume. Furthermore, no respirator, even though it well fits the face completely retards the passage of all lead dust. A 95% degree of efficiency may be regarded as well nigh perfect, but the 5% of ineffectiveness is often ample to provide exposures. Thus, in one point of the plant 500 milligrams of lead were found in an atmospheric sample. Thus if a 5% inefficiency of the respirator existed in the course of a work day period, 25 mgms. of lead might have been taken into the workman's body. This is more than 15 times as much lead as is required to bring about lead poisoning in some instances. In this plant there are many concentrations of lead where a 5% respirator inefficiency would still permit of practical exposures to lead.

Basophilic Aggregation Test in the Lead Poisoning Epidemic of 1934-1935*

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THE automobile production year 1934-1935 marks the outstanding epidemic of lead poisoning in this country for at least the past decade. This epidemic appeared in the automobile industry, which industry has been substantially free from lead poisoning since the abandonment of the dry-sanding of wooden bodies painted with lead-containing paints. This preceding epidemic was described by Dean in 1924.¹ The present epidemic has prevailed among the several thousand workers engaged in automobile body manufacture.

Recent trends in body design have led to one-piece, all-metal bodies with non-air-resisting contours. The manufacturing processes entailed call for the filling in of all welding depressions and other indentations with a lead-tin alloy. This leads to the use of molten lead pots and torch work, which in turn are followed by various processes for the smoothing down of the leaded surfaces, including power grinding, hand filing, sanding, etc. As a result the atmosphere of these workrooms is polluted by harmful quantities of lead dust and lead fume. Occasionally as much as 1,100 mg. of lead have been encountered in 10 cu. m. of air, which

amount of air approximates the quantity of air breathed by the average workman during the usual work day. However, the usual amount of lead in this quantity of air has ranged from 10 to 40 mg.

This type of lead exposure has brought about a high incidence of lead poisoning, together with the much larger groups of workers in whom proof of lead absorption has been established but who have not suffered subjective injury and have not lost time from employment. It is not possible to state the extent of lead poisoning during the past 12 months in the entire automobile industry. If the figures obtained from studies in a limited number of plants may be extended to the industry as a whole, it is possible that as many as 4,000 workmen have been injured to some extent during the 1934-1935 automobile production season. At best this figure is an approximation, and further it is emphasized that by no means does this number represent only actual clinical cases of lead poisoning.

During the past 10 years there have been many affirmations that industrial lead poisoning is a waning disease. While in some measure this has been true up until 1934, the outstanding fact is that it is the severity of the affection that is waning, rather than the frequency. Very strikingly this has been borne out by the present epidemic.

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As far as is known among the large number of cases, there have been no proved deaths, little profound encephalitis, very few instances of wrist drop or foot drop, etc. With certainty it may be believed that there have been milder degrees of neuromuscular injuries, encephalitis, etc. The outstanding and almost uniform manifestations have centered about involvement of the gastrointestinal tract, accompanied by excessive fatigability and blood changes.

Already the work conditions that produced this recent epidemic of lead poisoning have been modified in many plants to the extent that large numbers of additional cases of lead poisoning are unlikely. In some plants elaborate protective devices and procedures have been introduced. As yet no practical substitute has been found for the lead-tin alloy, inasmuch as certain other alloys that otherwise might be used may not be used due to prohibitive costs, undue shrinkage, etc. All in all, it may be stated that at least in some automobile plants the lead hazards have been brought under control.

This recent epidemic has provided us a long sought opportunity for the extended investigation of a diagnostic procedure first utilized by us in 1924.² Already a publication³ has been made on this recent experience up to the time that 1,600 tests had been carried out. At this time the results of nearly 8,000 tests are available for the appraisal of the method. This test is based upon the enumeration of the total number of basophilic containing cells in the blood, in distinction to the widely used procedure of enumerating preformed stipple cells, the value of which method is now somewhat questioned. The method as carried out is similar to that lately used by Jones and his associates.⁴ Since the basophilic formations as seen in the microscope do not exist as such in the blood stream and are artifactually produced in the

process of preparation and staining, we prefer to use the term "Basophilic Aggregations," which term uniformly appears in the subsequent discussion of this test and our experience with it, which now follow.

BASIC PRINCIPLES

In normal adult human life, the content of erythrocytes in the blood stream is maintained on a fairly uniform level by the orderly entry of new cells from the bone marrow replacing those that have been destroyed.

These new cells are essentially mature, only about 1 per cent exhibiting any of the several known characteristics of immaturity. In bone marrow, during the formative period of erythrocytes, an entirely different cytology takes place varying with the stage of development of the red cells. Readily there may be demonstrated nuclei, protoplasm, and basophilic substance. In due time a change not known for any other cells of the body occurs; a chemical (hemoglobin) replaces the protoplasm and the nucleus is extruded. The erythrocyte is then ready for its chief function in the circulatory blood. These phenomena are set forth admirably in Key's¹ fundamental paper on erythrocytic cytology. The mechanism which liberates cells when mature and conversely retains undeveloped cells is not known. However, the functioning of such a mechanism is well established.

Under conditions in which toxic agents exert an action on bone marrow, and under other conditions in which physiologic demands are made, increased numbers of erythrocytes enter the blood stream. As examples of the former may be cited lead, benzol, toluol, xylol, possibly arsenic and chlorinated hydrocarbons, such as carbon tetrachloride; of the latter the effects of high altitudes constitute an obvious instance. The chief charac-

teristic of these liberated immature cells is the presence of basophilic substance.

Polychromasia (polychromatophilia), punctate stippling, and reticulation are but different manifestations of one phenomenon—the presence of basophilic substance. The exact form of this basophilic substance existing in the unaltered blood is little known. Probably the picture observed as polychromasia after staining is nearest to the natural state of this material. The impression furnished by all available evidence is that of thousands of ultramicroscopic particles in acid suspension, or possibly in their innate form in acid solution. Reticulated cells probably are produced only as a result of laboratory manipulation and thus while not being true artifacts are laboratory creations. With suitable laboratory facilities one is able to observe through the microscope the actual formation of reticular processes in cells not previously exhibiting such reticulation. Through variations in laboratory technic, the experimenter may produce at will in a single blood smear all the well known varieties of reticulation, as fragmented, anastomosing, wreaths, mossy forms, etc. If the artificiality of reticulation be accepted as fact, then such terms as "reticulocytosis" conceivably may be regarded as anomalous, in so far as these terms betoken the existence of reticular forms in the circulating blood. However, stippled cells are believed to exist as such in the unaltered blood. Through unknown processes, the ultramicroscopic particles observed as polychromasia or the basophilic materials in acid solutions, are caused to arrange themselves into masses characteristic of stippling. From the literature these concepts are well borne out in substantial publications, brief excerpts from which are now recorded.

Key notes:

If an individual reticulated cell be watched carefully during the process of staining, the

net can be seen to grow under the eye of the observer as though it were being formed by precipitation of the substance from the surrounding medium.

It is difficult to conceive that fixatives cause a definite network to break up into ultramicroscopic particles and become uniformly distributed through the cell (*i.e.*, polychromatophilia). Fixatives tend to fix intracellular products *in situ*. It is consequently felt that the conclusion is warranted that the reticular network as seen in supravital stained erythrocytes is formed only during the process of staining and that no such structure exists in the unaltered erythrocyte.

My observations lead to the belief that the granules of punctate basophilia are formed of the same basophilic substance which in simple anemias gives pictures of polychromatophilia and that because of the pathologic process the substance is aggregated into small granules in the cell (punctate stippling).

With Wright's stain allowed to dry on a slide to which salt solution and blood is added, no polychromatophilia is seen but a definite basophilic reticulation slowly appears in the basophilic erythrocytes.

Basophilic substance (*i.e.*, as a term) is preferable to "reticular substance" since reticulations are artifacts due to the action of a stain on a substance distributed uniformly through the cell.

In Hawes's⁴ work no distinction was made between polychromatophilia and stippling, but when total percentages of the two were added the results corresponded with fair constancy with the total percentage of reticulated cells enumerated by other means on the same blood. Such differences as were encountered were attributed to differences in the delicacy of the methods used and not to any true excess of reticulated cells.

Jones⁵ observes: "This (basophilic) substance is demonstrated either in the form of polychromatophilia, punctate basophilia, or reticular designs, depending upon the staining method used."

Basophilic substance long has been regarded as the foremost blood finding in lead poisoning, but to an overwhelming extent reliance has been

placed upon the determination of stippled cells. Recognition that polychromatophilia, punctate stippling and reticulation are but different aspects of the same material, should prompt the placement of greater diagnostic dependence upon examinations for the totality of erythrocytes containing basophilic material. Of the three forms of basophilic substance, stippled cells are the least common. The positive diagnostic significance widely attached to the qualitative finding of stippled cells in suspected lead poisoning is becoming more and more questionable; conversely less uncertainty is believed to attend the quantitative determination of all basophilic erythrocytes.

TECHNICAL PROCEDURE

The blood of normal human adults rarely contains more than 1 per cent of basophilic erythrocytes. The average in our experience lies between 0.4 and 0.8 per cent. With workers absorbing lead without clinical manifestations and in early lead poisoning, the percentage commonly ranges from 1.5 to 4.0 per cent, with occasional findings up to 20.0 per cent. The zone between 1.0 and 1.5 per cent represents the threshold, findings within which being open to doubt. In the absence of other pathology, any finding in lead exposed workers of, or in excess of, 1.5 per cent at once suggests the probability of lead absorption. Findings in excess of 2.0 or 3.0 per cent are to be associated with an increased imminence of clinical lead poisoning.

Search for these basophilic forms is best made in laked cells. When laking takes place some of the basophilic substance probably leaves the cell with the hemoglobin. The remainder, being insoluble in water, salines, and some stains, collects in masses, strands, and reticula, as laboratory artifacts. Such forms are far more visible than poly-

chromatophilic cells and are more numerous than stippled cells.

In our first work² a thick, even blood smear was entirely laked. The number of basophilic aggregations in an average of many uniform microscopic fields was interpreted in relation to our clinical observations of the persons examined either as controls or as leaded patients. This procedure justly has been criticized as not readily transferable to others for quantitative work, since the making of uniformly thick smears by divers persons is most unlikely. Under rigid research conditions this earlier method will yield quantitative results but now is not the preferred procedure. The technic now employed is here presented:

The Sussmann-Weindel stain advocated by Jones is quite satisfactory when its several ingredients are pure. The formula is as follows:

Toluidine blue	0.5 gm.
Borax	0.05 gm.
Methylene blue solution (Loeffler's)	5 cc.
Distilled water	100 cc.

Our experience with this stain has been that it is not uniform from one batch to the next. Most of the trouble may be traced to the toluidine blue. Of six samples of this dye recently purchased by us from various supply houses, only one was found to be satisfactory.

A modified Manson's methylene blue yields more consistent results. The formula is as follows:

Borax	1.0 gm.
Methylene blue	2.0 gm.
Distilled water (boiling)	100 cc.

The borax is dissolved in the boiling distilled water and to this is added the methylene blue. After filtering, this stain is ready for use and provides a stable, satisfactory, and uniform stain for at least 2 weeks. If used for long periods, a progressive formation of

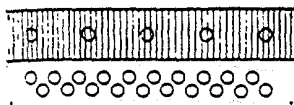


FIGURE I. Schematic arrangement indicating fixed (x, x) and unfixed (y, y) portions of slide, together with coating procedure on uniform slide.

precipitate may appear. However, due to the low cost and ease with which this stain is prepared, we consider this a small handicap. This stain is less stable than the Sussmann-Weindel, but in our experience gives more trustworthy results.

Thin, even blood smears are made on slides and allowed to dry. The proper drying of these smears becomes important. If permitted to become excessively dry, that is, longer than 12 hours, some of the basophilic containing cells will not lend themselves to aggregation of their basophilic material. On the other hand, insufficient drying facilitates removal of cells during the staining period. Ordinarily the optimum time lies between 1 and 3 hours. Under peculiar industrial conditions, involving high temperatures and low



FIGURE III. Typical microscopic field from fixed portion of same slide as in Figure II, presenting unstained, stained red blood cells. Lines of Whipple grid used as guide in counting may be seen.

humidity, or conversely high humidity, special consideration for the drying period may be required.

After drying, one-half of the slide is overlaid by a strip of filter paper, as set forth by Jones, and cautiously there is applied with a pipette or dropper the minimum amount of methyl alcohol C. P. (methanol, wood alcohol) required to moisten the filter paper until it clings to the slide. This is allowed

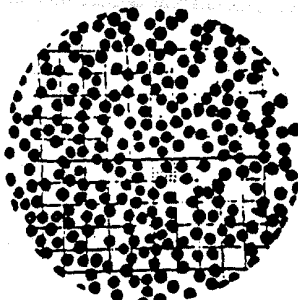


FIGURE II. Typical microscopic field from unfixed labeled portion of slide presenting numerous basophilic aggregations.



FIGURE IV. Semi-schematic drawing of a basophilic aggregation in labeled red blood cell. Mammalian stain. Magnification in original drawing: 17,000.

to dry until the filter paper becomes loose.

The slide is now submersed in a Coplin staining jar, containing the Manson stain, for approximately 10 minutes. The time is of minor importance since a readable stain may be had in 2 minutes, and on the other extreme it is impossible to overstain. After staining, it is necessary to wash the slides through 3 or 4 rinses of distilled water. In some cities tap water may be safely used for this purpose. Air drying of the slides is recommended.

The microscopic arrangements as used by us provide an oil immersion objective and a 10X ocular, which is fitted with a Whipple grid. The outer lines of this grid determine our microscopic field (Figure III). The average field in a good preparation contains approximately 150 red blood cells. Before counting, the slide should be examined for an area showing suitable distribution of the red cells. In the unfixed portion of the slide, customarily 10 consecutive fields in two parallel rows are counted, making a total of 20 fields, but in the more evenly distributed slide 20 consecutive fields. Then moving to the fixed portion of the slide, 5 appropriately corresponding fields are counted (Figure I). The basophilic aggregations are then expressed as a percentage of the latter.

Thus, if in the 20 fields counted in the unfixed portion of the slide there were found 76 B.A.s (Basophilic Aggregations), and if in the 5 fields of the fixed portion 1,000 red blood cells (or 4,000 in 20 fields), the obvious percentage is 1.9.

The physical features of the B.A.s are best presented in the accompanying photographs and photomicrographs (Figures II, IV). The color of the cells varies with the stain employed. A clear, brilliant blue is obtained with the Manson stain. A hand tally is used in the enumeration of the cells.

RECENT RESULTS

During 1934 and the first two-thirds of 1935, approximately 8,000 examinations were made, using the technic just described. The examinees represent employees in 16 plants and 6 different industries. Included in the 8,000 tests made are several hundred controls usually obtained from office groups. The lead exposed workers were distributed over the following industries: lead pigment manufacture, paint and other coatings manufacture, soldering, lead casting, lead oxide manufacture and application, and lead smelting. In some plants, but not all, concurrent determinations were made as to the amount of lead in the atmosphere expressed in terms of mgs. of lead per 10 cu. m. of air. In the aggregate, 416 quantitative lead determinations were made. The results from the basophilic aggregation tests have been correlated with the findings of the quantity of lead in the atmosphere breathed by exposed workers.

During 1934, basophilic aggregation tests were carried out simultaneously with stipple cell determinations, and in some instances with hemoglobin measurements and total red cell counts. Very early it was established that no consistent correlation was present. In many persons wholly unexposed to lead an occasional stipple cell was encountered and among lead workers approximately 90 per cent presented large numbers of stipple cells in the absence of clinical lead poisoning, and often after 3 months of no exposure to lead. The number of stipple cells in lead-using workers without clinical lead poisoning ordinarily was lower than 3,000 per million. The qualitative demonstration of stipple cells proved of no value in the diagnosis of clinical lead poisoning or in the making of decisions as to acceptability of men for continued work. Many workers regularly exhibiting stipple cells in

their blood smears passed through the entire automobile production season without illness and without any lost time. In similar fashion it was found that no significant diagnostic values resided in the routine determination of hemoglobin percentages or in total red cell counts. Over and over high percentages of basophilic aggregations were detected with no significant changes either in the hemoglobin or in the erythrocyte counts. For this reason all blood work other than the basophilic aggregation tests was abandoned as routine procedure in plant surveys, although complete blood work was carried out in the management of clinical cases of lead poisoning.

The trend of findings from 3,000 basophilic aggregation tests are now shown in three specimen tables.

Table I comprises the results from 25 representative controls. In establishing normal ranges of basophilic cells only such persons were utilized as

Initials	Age	Per Cent Basophilic Cells	Length of Time on Present Job
C. S.	41	2.1	14 years
V. D.	37	1.2	8 years
J. M.	46	1.4	6 years
T. K.	34	3.5	9 years
J. K.	46	1.1	7 years
G. F.	41	3.2	1 year
A. S.	47	3.1	4 months
D. T.	35	1.3	6 years
G. B.	17	0.4	2 years
G. K.	30	1.5	10 months
T. M.	35	5.5	2 months
K. W.	29	1.6	5 years
E. G.	33	0.7	3 years
S. P.	30	2.0	5 years
V. T.	38	1.6	4 months
A. C.	36	3.3	1 month
F. N.	45	1.7	8 years
S. M.	38	1.4	3 years
J. G.	33	2.5	6 years
J. C.	32	0.5	2 years
C. C.	27	1.4	3 years
F. L.	40	2.4	4 years
J. S.	33	2.5	6 years
L. K.	47	1.9	6 years
C. H.	30	1.3	21 years

were known to be essentially unexposed to lead and definitely unexposed in industrial pursuits. Almost without exception control examinees present less than 1 per cent of basophilic containing cells.

In Table II may be found the results of 25 workers in an atmosphere containing lead to the extent of 14 mgs. per 10 cu. m. of air. In contrast to the control table just preceding, a fair number of these examinees present findings above 1.5 per cent. It is among workers having such findings as these that clinical cases of lead poisoning may be expected to arise. Almost uniformly it has been noted that the higher the lead content of the atmosphere the higher the percentage of exposed workers showing positive basophilic aggregation findings. On the other hand it has not been found that the percentage of basophilic cells increases with any uniformity in keeping with increases in the lead content of the atmosphere. An occasional worker may yield as high a figure as 10 or 15 per cent of B.A.s but this is not the rule and the majority of affected

TABLE I

Initials	Per Cent Basophilic Cells
R. T.	0.4
E. T.	0.7
J. J.	0.4
L. H.	0.9
G. O.	0.5
S. M.	0.3
K. F.	0.6
R. H.	0.3
H. D.	0.9
M. G.	0.4
G. C.	0.5
O. L.	0.4
W. F.	0.2
J. B.	0.7
F. W.	0.4
H. K.	0.6
W. B.	0.2
J. R.	0.3
H. F.	0.7
W. K.	0.5
E. S.	0.3
C. W.	0.6
R. B.	0.3
L. K.	0.6
C. V.	0.4

workers regardless of the amount of the exposure will present positive findings in the range of from 2 to 6 per cent.

With the procurement of better work conditions, as reflected by lowered quantities of lead in the atmosphere, there occurs a corresponding diminution in the number of persons showing positive tests, although there is a lag of from 1 to 2 weeks before this drop may be demonstrated. This correlation between lead in the atmosphere and positive blood smears is reflected in Table III.

TABLE III

BASOPHILIC AGGREGATION TEST RESULTS ON WORKERS BEFORE AND AFTER THE LEAD CONCENTRATION WAS REDUCED FROM 75 MG. PER 10 CU. M. OF AIR TO 4 MG. PER 10 CU. M. OF AIR. ELAPSED TIME: 35 DAYS.

Initials	Per Cent B. A. Cells When 10 cu. m. of Air Contained 75 mg. of Lead	Per Cent B. A. Cells When 10 cu. m. of Air Contained 4 mg. of Lead
M. V.	2.0	0.8
T. S.	2.1	0.7
A. L.	2.0	1.0
J. B.	3.2	4.6
W. H.	2.0	0.9
C. H.	3.4	1.4
J. T.	2.1	0.6
K. S.	2.7	2.0
C. S.	4.3	3.4
C. M.	2.4	1.6
V. K.	2.4	0.5
M. S.	3.0	0.9
C. G.	2.0	0.8
C. B.	2.0	1.0
J. E.	2.0	1.7
D. D.	2.5	2.2
D. T.	2.2	2.2
W. W.	1.1	4.0
J. K.	3.2	1.3
G. B.	3.0	0.8
G. C.	2.0	0.5
J. P.	2.1	1.4
A. R.	2.0	0.5
T. L.	3.1	2.4
P. P.	6.5	5.3

This specimen material is characteristic of the entire investigation, with one exception. In one plant, manufacturing a great variety of pigment materials, lead poisoning was known to be present but the basophilic aggregation tests were not found to be in keeping with our general experience. The assumption is that because of the

multiplicity of chemicals manipulated some biological antagonistic factor interfered with the usual reaction of the embryonic red cell to lead.

The chief application of this test has been in the routine examination of large groups of lead exposed workers. The results of such tests have been utilized as a guide for the transfer of workers to less hazardous departments, in the appraisal of the degree of exposure in different departments, in determining the effect of preventive measures, and in the differential diagnosis between lead poisoning and conditions simulating this disease, but in routine work its greatest single value has been associated with the detection of malingers. During this epidemic in some plants, as high as 90 per cent of all exposed workers have simulated lead poisoning presumably in order to be eligible for insurance and sick benefits during the nonproductive season in the automobile industry. In some instances this basophilic aggregation test has been accepted as a sufficient criterion for the weeding out of these malingers.

GENERAL COMMENT

In persons exposed to lead, otherwise free from disease, the detection of basophilic containing red cells in percentages in excess of 1.5, and particularly in excess of 2 per cent, suggests lead absorption and the possibility of approaching clinical lead poisoning.

Inconclusive proof is available that this test may be positive after exposure to other substances such as benzol, toluol, xylol, arsenic, etc. Occasionally in infectious diseases numbers of basophilic aggregations above the usual may be found. Manifestly in anemias and other types of diseases involving the red blood cells, normal ranges may be exceeded.

The length of exposure to lead ap-

pears to have no significant bearing upon the basophilic aggregation findings. Two weeks' exposure is ample to bring about increased numbers of basophilic containing red cells. New workers employed alongside of workers employed for a longer period are prone to show a greater frequency of response than the older workers.

In prolonged chronic lead poisoning the test described appears to be of limited value. The recession in the number of basophilic aggregations may be definite in long existing lead poisoning even in the presence of frank manifestations. Under such conditions punctate stippling may persist.

In many publications the minimum amount of lead that may lead to lead poisoning is specified as from 1 to 2 mg. as a daily intake. While this figure may represent a primary threshold at which an occasional case of lead poisoning may arise, it is our experience that many hundreds of workers continue at employment in concentrations much higher without demonstrable impairment. Without denying the possibility that a daily intake of 1.5 mg. of lead may produce lead poisoning, the belief is expressed that the practical threshold may be considerably higher and in the general range of from 4 to 8 mg. At least, years of exposure to such concentrations have not led to a single recognized case of plumbism in several plants included in this investigation.

One of the practical advantages served by this test as described lies in the fact that large numbers of persons may be examined daily. In our experience, a single worker has been able to collect as many as 300 specimens per day. Laking, staining, and cell counting, subsequently carried out, necessarily must be at a slower rate, but on a single day, as many as 70 counts have been made by one experienced technician. This rate of work

stands in contrast to stipple cell enumeration, which if properly carried out ordinarily yields not more than 20 determinations daily.

SUMMARY

In the 1934-1935 epidemic of lead poisoning in the automobile industry, 6,900 basophilic aggregation examinations of the blood were made. In addition during this period 1,100 tests were made in other industries, thereby totalling 8,000 tests during the investigation. This number includes approximately 500 control examinations made upon workers unexposed to lead.

Positive basophilic aggregation tests, the method for which is described in detail, have served as an index for lead absorption prior to the appearance of clinical manifestations of lead poisoning. This test has proved to be of value in the diagnosis of early cases of lead poisoning. An approach to this test was described by us in 1924. Through technical improvements, made by others and by us, this procedure is now suited to application by any physician or laboratory carrying out any blood examinations.

The basic principle in the basophilic aggregation test is the enumeration of red blood cells containing basophilic substance, in contrast to the customary procedure of qualitative or quantitative examination for stipple or polychromatophilic cells.

The native state of basophilic material in unaltered red blood cells is not known, but in the process of laking and staining red cells this substance may be artificially aggregated into readily visible masses. In normal human adults, these aggregates rarely exceed 1 per cent of the total number of erythrocytes, but in lead exposed individuals the percentages ordinarily lie above this normal maximum, when considerable lead is being absorbed or when clinical lead poisoning is im-

minent. Findings of percentages above 1 to 1.5 per cent and especially above 2 per cent in persons exposed to lead at once suggest lead absorption and the possibility of approaching lead poisoning, or the actuality of early lead poisoning.

In chronic lead poisoning this test usually is not, but may be, positive. As lead poisoning progresses to extended chronicity, the reliability of the procedure diminishes. This test has been utilized in lead-using industries to determine the number of exposed workers absorbing lead, as some proof of existing lead hazards, as a guide for the transfer of lead absorbing workers to lead-free departments, as a measure of the efficacy of preventive devices and practices, and as a means for the detection of malingers.

There are varied types of diseases leading to positive basophilic aggrega-

tion tests, but in groups of workers in lead industries, presumably normal except for the possible effects of lead exposures, the positive basophilic aggregation test stands in some relation to lead absorption and its subsequent action.

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TOXIC VAPORS

In this plant, as is true for all paint manufacturing plants, one of the foremost trouble makers in terms of toxic substances is to be found in the vapors arising from various solvents, thinners, etc. In this plant, there are scores of individual substances and an even larger number of mixtures of primary substances. These include: benzol, toluol, xylol, solvent naphtha, naphtha, mineral spirits, kerosene, ethanol, butanol, methanol, a variety of acetates, cellosolves, varnishes, thinners, paint removers, acetones, ketones, turpentines, pine oils, chlorinated compounds.

These classes of fluids give off vapors, some of which are exceedingly toxic. At the top of the list in this particular plant, among substances in extensive use, are benzol, toluol, solvent naphtha, methanol, butanol, among others.

It is most difficult to measure the greater number of these substances even as chemical entities and vastly more difficult when in the form of mixtures. It is very seldom in this plant that any vapor exists in pure form. Thus in the Lacquer Department, where vapors are frequently present in disturbing concentrations, no less than six or eight volatile materials have contributed to the vapor mixture. Moreover, this mixture probably varies in constituency from hour to hour and certainly from week to week.

On this account, determinations such as shortly are to be reported are at best approximations. Various types of equipment might be utilized, ranging from interferometers to thermal-conductivity equipment. In this plant, there was employed a compact gas ratio apparatus, designed especially for use in connection with gases or vapors that may explode, or which at least are combustible. This machine was taken to several portions of the plant where combustible vapors might be present. The results obtained are expressed in terms of percentages of the explosion point.

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The threshold of toxicity for these combustible vapors is naturally very much lower than the explosion concentration. Thus, for example, benzol vapors are explosive in the general concentrations represented by 20000 parts per million, while the threshold of toxicity is only 100 parts per million. This limit of course does not apply to all members of the combustible group, but always the toxicity threshold is lower than the explosion threshold. The results from many tests are now shown:

Points for measurements were selected wherever evolution of vapors of combustible nature was suspected. For example, in the Lacquer Department, a good deal of such is found arising from the various solvents used. Attempt was made to reproduce winter work conditions, but this is not fully possible in mild weather.

1) Basement of thinner room in tankage yard:

With agitator shut off	6%	doors closed
With agitator running	12%	

2) Main floor, thinner room, doors open, with good breeze while filling drums with xylol, 4" from nozzle 10%

3) Building 546, Lacquer Storage, during pumping over of toluol, doors closed

Floor	6%
Top of Tank	16%

4) Building 546, Lacquer

Cleaning drum	100% (in drum)
Work Position	26%
At Portable Mixer, w.p.	34%
(Rx OLL732)	
Centrifuge operating	6%
Stirring kettle	24%

5) Building 544

Emptying lacquer base (#2617)	20%
Over Mixing Tubs	4%
Filling Nitrocellulose	4%
Mixing tub during addition of thinner by pipe	8%
Filling room after application of cleaner-remover mixture to floor	10%

6) Building 517, Drum Cleaning

Work Positions	10%, 19%, 3%, 4%
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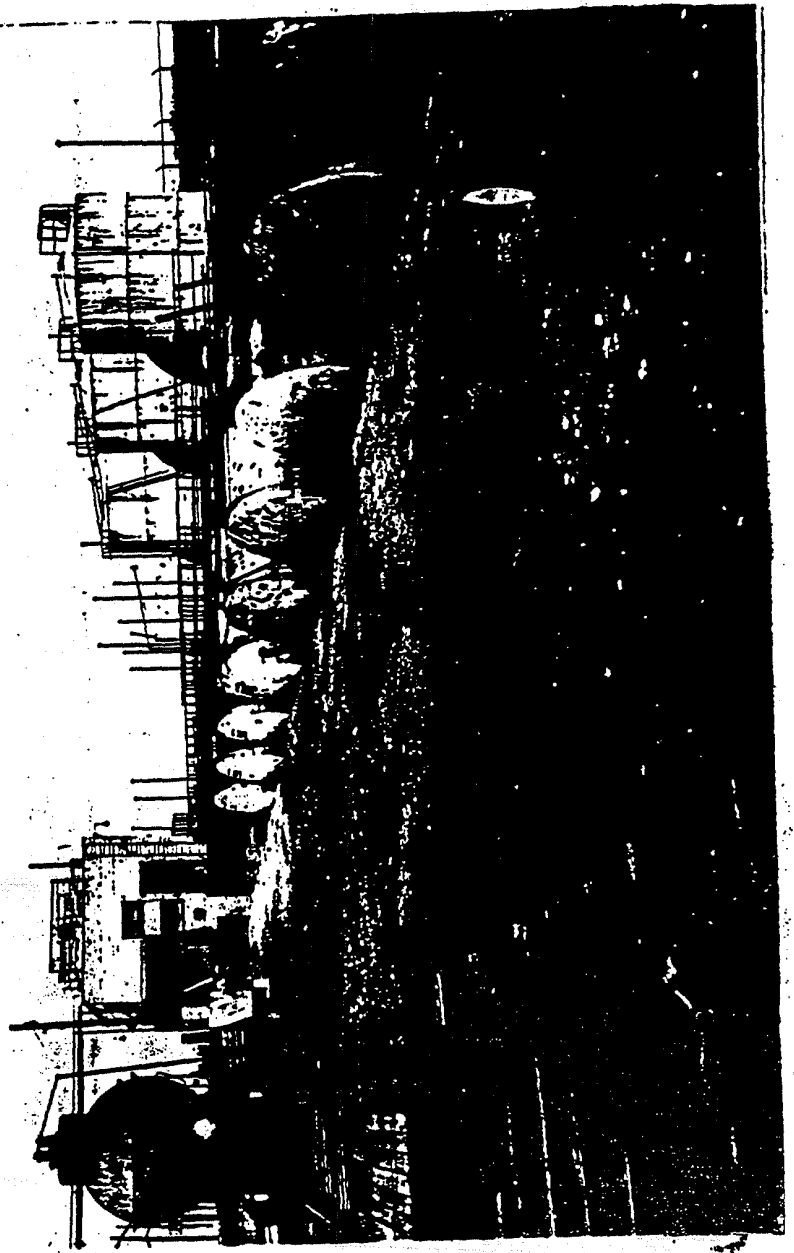
Using the standard cleaner-remover in use at this plant. It is claimed that volatile fumes are worse when #241 and #534 (gun solvents) are used.

7)

Building 515, dissolving nitrocellulose:
After mixing acetone and nitrocellulose through manhole
Work Position 40%

Benzol is used here in some formulae at some times.
Ventilation is poor.

Filter Press Cleaning (W.P.)	10%
------------------------------	-----



The Outside Storage of Inflammable and Toxic
Liquids is Often Desirable and Where Practical
Is Commendable

8) Building 570

Panel Cleaning, at vat 6%

In winter the worker claims it is "very close" and the cold comes up through the floor so he cannot properly ventilate the room which is very small. He claims no worker has stayed on this job because of unpleasant symptoms arising. He states that he has "stomach trouble", anorexia, headache, vertigo, somnolence, etc. in winter, but in summer he is free because of the ventilation. He has been on the present job for four years.

9) Varnish Thinning Room

Naphtha being used, work position 2%, 20%

10) Varnish Filling

Naphtha used 46%
Benzine " 8%

11) "Toxite" filling (contains benzol) 4%

12) "Toxite" mixing

Tank "alk 3%
Cover open 10%

13) White Shellac Filtering 10%

14) Benzol storage

without fan 10%
with fan, 5 min. 5%

15) "Benzol" mixing, at tank
(Coal Tar Plant--open air
process) 60%

It is necessary to conclude that in many portions of the plant, undesirable concentrations of vapors are present and that in many instances the type of vapors are such as to make dangerous intoxication possible. These findings lead to recommendations for improvement in some instances, but these recommendations appear in other sections of this report, devoted to such purposes.

CARBON MONOXIDE ESTIMATIONS

Estimations were made of carbon monoxide at points where there was suspicion of incomplete combustion with consequent carbon monoxide evolution. Search was made for instances such as evaporating linseed oil on floors. Tests were made under circumstances most likely to favor evolution of carbon monoxide; for example, shortly after a flame in a furnace is lighted. No significant concentrations of carbon monoxide were found at any point. Several readings fell around .5 to 1 parts per ^{ten thousand} million, but it is to be emphasized that the instrument used (Mines Safety Appliance Company Carbon Monoxide Detector) is quite unstable over the range of about the first three units (parts per ^{ten thousand} million). Care was exercised to get actual work points and approximately fair conditions, with outside influences such as breeze, eliminated or compensated for. Of course, estimations made in winter, when doors and windows are closed for long periods, may give different results, since it is difficult to reproduce these conditions in autumn.

The readings now follow:

Tin Can Plant

Welding Machine, Line #1	
5' outside hood	0
5' inside hood	0
Welding Machine, Line #4	
At work position	.5 p.p.t.
Coating Nozzles	
Work position	0
Handle Soldering	
Work position	0
Nozzle Machine, Line 7	0
North Soldering Station,	
Hand	0
Machine Shop	
Muffle Furnace (1 ft.	
in front)	
at 650°F	0
at 1000°F	0
Oven Furnace, (1 ft.	
in front)	
at 1000°F	0
at 1500°F	0
Open Furnace, (12 in.	
in front)	0
Between 2 large furnaces,	
5' from floor	0

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Calcium Plant

Melting Kettle	
work position	0
Over mold with fire	0

Black Ash

Over rotary kiln with	
suffocating fumes	1.0 p.p.t.

Witherone Rotary Kilns

At gas gauges	0
At gas gauges	0

Red Banner, Doors Closed

Work position	0
---------------	---

Carbon Dioxide Generating Plant

Boiler room, fire door	
position	
(Building closed up 5 min.)	0

Witherone and Red Iron

Top No. 5 furnace	0
Top No. 4 furnace	0

Roller Room of Power Plant

Widale at work position	0
-------------------------	---

Wardish Tilters

At work position (brease)	0
---------------------------	---

Engels Custom Rate Plant

At Fire Position, work point	0
------------------------------	---

It is never possible to circumscribe any plant from the possibilities of carbon monoxide gas exposures. Conditions may vary from month to month because of defects in equipment and may vary from season to season because carbon monoxide gas is more especially associated with cold weather. In this plant it is noted that no substantial hazards exist, but in two places, namely at one point in the Tin Can Factory and another connected with Black Ash work, appreciable quantities of carbon monoxide have been detected. Around the black ash kiln room, complaints have arisen that gas is present, but more attention should be paid to hydrogen sulfide gas there present than the carbon monoxide, although both are important. Recommendations covering these gases appear in special sections devoted to these respective departments.

CADMIUM EXPOSURES

In the preparation of zinc for use in lithopons, it is necessary and profitable to remove the cadmium content. This is done at this plant rather than as one of the preliminary steps carried out at Coffeyville. Also, at this plant, a fair amount of cadmium finds application in connection with dry color and other pigment work.

Because cadmium is a decidedly toxic substance, a fair amount of attention has been paid to its use here, since its toxic properties are much less known than is true for such metals as lead.

There shortly follows a series of excerpts, summarizing the present day knowledge of cadmium poisoning. These items are derived from the publications prepared by Dr. McCord, which in turn are in part derived from other publications.

A review of the literature on cadmium poisoning shows that up to the present time most of the work has had to do with the physiologic and pharmacologic action of the metal. The pathologic changes reported, with the exception of the changes in the kidneys, are only suppositions with no confirmatory evidence. Many valuable data on feeding experiments are given, but only one experiment on exposure through the respiratory system was found, and this was very incomplete. From the standpoint of industrial hygiene, the experiments on the respiratory system are of capital importance because of the greater possibilities of exposure through this system and the far more damaging consequences.

From the published observations on experimental cadmium poisoning the following conclusions may be drawn:

1. Cadmium in relatively small doses is lethal for different experimental animals (dogs, cats, rabbits, frogs, etc.)
2. Cadmium has a direct paralyzing action on the central nervous system and also on the vasomotor system.
3. Cadmium induces vomiting when given orally and also when introduced into the general circulation, and produces a general toxic effect.
4. When introduced into the organism (whether orally or by injections) cadmium has a tendency to be stored up, mainly in the liver and the kidneys.
5. The elimination of cadmium from the organism is very slow and is effected through the kidneys and the gastro-intestinal tract. At autopsy, animals fed or injected with cadmium show a fatty condition of the liver and nephritis.
6. Cadmium taken through the respiratory system gives a generalized pneumonia and sometimes pleural effusion.
7. The feeding experiments show a decrease in the hemoglobin content of the blood, and exposure through the respiratory system an increase. In both cases a relative increase in the polymorphonuclear leukocytes takes place.

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8. Cadmium has no practical importance as a therapeutic and bactericidal agent.

The greatest health hazards for humans are found in the manufacture of cadmium and in the handling of the compounds. The following list shows where the most hazardous exposures have been encountered:

1. Vapor or fume from the retorts or condensers of the blue powder furnaces, in making both cadmium and cadmium oxide.
2. Fume from and near the collecting bags in making cadmium oxide. The particles which constitute this fume are so small that a large percentage of them are not caught in the bags.
3. Dust in handling cadmium oxide, as such, especially in emptying the bags and packing.
4. Fumes from working up the blue powder furnace residues at the furnace and in the bag room.
5. Shaking the bags in the bag room (blue powder) of the zinc smelting kiln.
6. Emptying the blue powder from the bags of the zinc smelting kiln, storing it, and transferring it to the blue powder furnace or for the wet treatment.
7. Working up the blue powder by the wet method—that is, handling the blue powder and the solutions with high concentrations of cadmium.
8. Handling the metal residues stored for drying.
9. Manufacturing and handling lithopone and working up the residues from this process.
10. Manufacturing and handling cadmium sulphide.
11. Spraying cadmium sulphide (as a paint).
12. Welding alloys containing cadmium or cadmium-coated articles.
13. Melting metallic cadmium or its compounds without adequate ventilation.
14. Handling any cadmium compounds which may be inhaled or ingested.
15. Using cadmium coated or plated articles for any purpose where they come in contact with food or drink.

It may be mentioned here that the oxide is sometimes used as a source of cadmium in cadmium lithopone manufacturing, in cadmium plating, and in the manufacture of cadmium sulphide.

It is not yet known how great a health hazard there may be in the process of cadmium plating after the cadmium is in solution. The only observation which has been made up to this time is that the solution coming in contact with the skin causes it to turn black.

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The presence of arsine in the manufacture of cadmium constitutes a further health hazard; and the fire hazard in connection with the blue powder and the cadmium sulphide should also be noted.

Summary and Conclusions:

A thorough review of the literature showed that the work done on cadmium was considerable varied, but unsatisfactory from the standpoint of the industrial hygienist. Although industrial cadmium poisoning occurs practically entirely through the respiratory system, the least work was done in this direction. Even in feeding experiments the pathologic changes were not precisely determined since they were not verified by microscopic examination. Much has been achieved, therefore, in the present study which presents valuable information for the industrial hygienist.

Following are some of the general manifestations known to arise in human beings as a result of cadmium poisoning:

Various investigators have held that cadmium gives a definite inflammation of the mucous membranes of the gastro-intestinal tract, emaciation and loss of weight and fatty degeneration of the heart and kidneys. A modification of the blood picture which includes diminution of the hemoglobin, of the number of red cells, of the polymorphonuclear and an increase of the lymphocytes, irritation of the conjunctivitis and the mucous of the respiratory passages. Some investigators have also noted an irritation of the conjunctiva of the eye.

In the various cases of cadmium poisoning reported in the literature, the following symptoms have been noticed: dryness of the throat, headache, rapid pulse, nausea, brown color of the urine, weakness, lack of appetite and shivering. Autopsy in some of these cases showed signs of congestion of the larynx, the trachea and bronchial tubes, acute inflammation of the stomach and intestines, fatty degeneration of the heart and liver, hemorrhagic inflammation of the spleen and inflammation of the kidneys.

Various investigators have reported that the symptoms of cadmium poisoning resemble those of lead poisoning, except that the characteristic colic in lead poisoning has not been noted. Cadmium taken through the respiratory system has been reported as giving pneumonia and sometimes pleural effusion. Cadmium has a direct paralyzing action on the central

nervous system and also on the vasomotor system.

Up to this time it is almost impossible to state with certainty just what concentration of cadmium constitutes the threshold of danger for human beings. Various experimental studies have yielded results indicating that a very few milligrams of cadmium or its compounds per kilo of body weight of test animals leads to demonstrable ill effects. It is not justifiable to apply these same figures to human beings. But it is known that as little as 33 milligrams (approximating one-half grain) will produce prompt vomiting in man. Manifestly, the threshold is well below this point, and is perhaps near ten milligrams.

Cadmium is to be accepted as of the same order of toxicity as lead, arsenic, and mercury when the portal of entry is by way of inhalation or subcutaneous or intravenous injection. However, when the route of entry is the alimentary tract, the order of toxicity is lower and is more nearly comparable to zinc.

The entire situation as to the toxicity of cadmium for human beings is considerably confused. Too much emphasis may have been placed on the results of animal experiments and too few actual cases of human intoxication have developed upon which to predicate definite appraisals. It is possible that the entire matter insofar as involving human beings is somewhat exaggerated.

Cadmium Analyses

Because of apprehension over the cadmium recovery work at this plant, three samples were collected in order to determine the content of cadmium in the air, such as might be breathed by workmen in the course of the day's work. No precisely accurate method for cadmium determination is well known or widely used. At this time, a method is being studied in our laboratories in Detroit and this method has been applied. The results obtained now follow:

<u>Sample No.</u>	<u>Mg. Cadmium per 10 cu. meters air</u>	<u>Sampling Point</u>
58	.91	Cadmium reclaiming—2nd floor, Building #209—10 feet from smelter, near precipitation tubs. Strong wind from west carried smoke and fumes toward sampling point.

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<u>Sample No.</u>	<u>Mg. Cadmium</u> <u>per 10 cu. meters air</u>	<u>Sampling Point</u>
59	.21	3 feet west of cadmium smelter
60	.10	Approximately 2 feet in front of workman during pouring of cadmium pigs; about 5 feet northwest of smelter.

(.2 is threshold of danger)

From the foregoing, it is established within the limits of accuracy of the method employed that an unusual amount of cadmium is thrown into the atmosphere in the cadmium recovery plant. This quantity is well above the minimum believed to cause cadmium poisoning. The absence of poisoning is probably due only to the fact that this work is intermittent and somewhat irregular. No less, in connection with recommendations for the Lithopone Department, definite suggestions have been made seeking the amelioration of what is believed to be an undesirable set of work conditions.

One worker in this department complains of severe dryness of the throat which is usually associated with cadmium poisoning.

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HYDROGEN SULFIDE

This gas is a very dangerous one, falling into the same toxicity range as hydrocyanic acid gas.

Hydrogen sulfide was suspected in several places, chiefly because of the odors present. Tests were made in three of these locations with the Mines Safety Appliance Hydrogen Sulfide Detector.

- 1) Lithopone striker tubs, during addition of acid at manhole
..... below .001 (10 p.p.m.)

(A strong draft up the stack exists here and while the odor of hydrogen sulfide was detected once over the manhole during the addition of this acid, the detector failed to reveal the presence of significant concentration at the work position.)

- 2) Before lithopone driers where strong hydrogen sulfide odor exists
..... below .001 (10 p.p.m.)
- 3) Black Ash, atop rotary kiln in presence of suffocating odors, but not definite hydrogen sulfide odor.
..... below .001 (10 p.p.m.)
- 4) Black Ash, general atmosphere, raining outside.
..... below .001 (10 p.p.m.)

Although the quantities of gas detected are slight, and limited to a few places, it is believed that enough danger exists to warrant preventive measures. These are discussed in that section of this report devoted to conditions in these departments.

In this connection see special section devoted to warehouses at 104th and 108th Streets.

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URINE SULFATE DETERMINATIONS ON BENZOL WORKERS

The use of benzol appears to be on the increase in the paint industry at this time. For a number of years benzol was largely eliminated, with the exception of its use in paint and varnish removers. In spite of many statements around this plant that benzol is practically unused, the total annual consumption indicates a comparatively high use. Further evidence of increased use is found in the fact that a benzol producing plant is being built here during the period of this investigation and this plant will have a daily output of approximately 1500 gallons of benzol.

Any increased use of benzol is regretted by the industrial hygienists, but at no time should the attitude be taken that dangerous substances should not be used. Instead, ways and means should be found to make the use of dangerous substances compatible with complete safety.

If it be true that benzol use is on the upgrade, it may be observed that circumstances for protecting workers are now better than years ago, owing to the recent development of a peculiar test which apparently indicates whether a benzol worker is absorbing benzol. This test was devised by governmental officials, working in the Bureau of Mines in Pittsburgh, by using funds provided by private agencies, chiefly the Barrett Company. This test has been described in many publications, one of which is here cited: Urine Sulfate Determinations As A Measure of Benzene Exposure, by W. P. Yant, H.H. Schrenk, R.R. Sayers, A.A. Horvath and W.H. Reinhart, J. Indus. Hygiene and Toxicology, Vol. 18, No. 1, January, 1936, pg. 69.

The following materials, dealing with the urine sulfate test, are excerpted from a publication of the Barrett Company.

URINE SULFATE TEST AS A MEASURE OF BENZOL EXPOSURE

Urine sulfate ratio is the amount of inorganic sulfates in the urine, divided by the amount of total sulfates.

The urine sulfate ratio is a measure of the amount of benzol vapors inhaled by the individual tested. It gives a definite warning signal of danger to exposure before the health of the individual is in any way affected.



Paint and Varnish Remover Filling. Since Benzol
is Used as a Constituent, Definite Exposures May
Exist in the Absence of Carefully Designed
Protection

<u>Urine Sulfate Ratios</u>	<u>Benzol Hazard</u>	<u>Precautions Indicated</u>
Above 75%	No exposure	Normal range of sulfates
Below 50%	Unsafe	Additional ventilation is necessary
Below 25%	Dangerous	Stop exposure until ventilation is improved

The test has no diagnostic value, that is, it tells nothing about the health of the individual at the time the test is made, hence the test can be made by the factory chemist.

The urine specimen should be taken after the individual has been working three to four days. Do not make test on Monday if the employee is off on Sunday.

Take the specimen at the end of the working shift—not at the beginning of the working shift.

METHOD OF ANALYSIS OF URINE SPECIMENS

Inorganic Sulfates—Twenty-five cc. of urine, 100 cc. of water and 10 cc. of dilute hydrochloric acid (1 part concentrated HCl and 4 parts water by volume) are measured into a 200-250 cc. Erlenmeyer flask. If the urine is dilute (a dilute specimen may be recognized by its weak color or by specific gravity test less than 1.005) 100 cc. of urine is taken and 4 cc. of concentrated HCl is added, 25 cc. of water may be added. Ten cc. of a 5% barium chloride solution is added slowly, drop by drop. The urine solution should not be shaken, stirred, or otherwise disturbed while the barium chloride is being added. The solution is allowed to stand an hour or longer, according to convenience, then shaken up and filtered through a Gooch crucible. (No. 42 Whatman filter paper may be substituted for Gooch crucible). The precipitate is washed with about 250 cc. of cold water, dried, ignited and weighed.

Specimen for above test should be placed on ice immediately after voiding unless test is made at once. Barium chloride should be added within 24 hours.

Total Sulfates. Twenty-five cc. of urine and 20 cc. of dilute hydrochloric acid (1 to 4), or 100 cc. of dilute urine and 8 cc. of concentrated HCl, are boiled gently in an Erlenmeyer flask (200-250 cc) for 20-30 minutes. The mouth of the flask should be covered with a small watch glass to retard loss of steam during the boiling. The flask is cooled in running water for 2-3 minutes and the contents diluted to about 150 cc. with cold water. To this cold solution 10 cc. of 5 per cent barium chloride is added and the procedure continued as described under "Inorganic Sulfates."

This test has been applied to 14 workers who are here exposed to benzol or to similar materials. The results are now shown:

<u>Check No.</u>	<u>Name</u>	<u>Occupation</u>	<u>% Inorganic Sulfates</u>
302		H Dept., Taxite,	80
2451	REDACTED	P & V remover	
		Panel Cleaner	97
2467		Drum Cleaning	94
2464		Drum Cleaning	91
2462		Drum Cleaning	92
2470		Drum Cleaning	88
2477		Drum Cleaning	-
2509		Drum Cleaning	-
2513		Drum Cleaning	90
2516		Drum Cleaning	86
2460		Base Lacquer	90
2487		Base Lacquer	85
Mo.		Base Lacquer	92
2452		Lacquer Dept, Mixer	24

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It is noted that one person only falls into the highly dangerous zone, this being a lacquer mixer.

RECOMMENDATIONS

It is recommended that some division of the general chemical works in this plant be charged with the responsibility to carry out at least monthly tests on all workers considerably exposed to benzol. The responsibility for procuring these tests and appraising the results should be made the responsibility of the Medical Department. Whenever tests indicate a percentage lower than 50, the attitude should be taken that additional safeguards are in order. Also, such a finding should lead to the physical examination of workers and to the making of differential blood counts to determine the presence of a leukopenia.

It is the opinion of these investigators that the benzol situation in this plant so far as worker protection is concerned is not good. Additional comment is made in various other sections

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ILLUMINATION

In presenting extensive material on the lighting of this plant, it must be emphasized that the observations made and conclusions drawn are purely suggestive. Certain readings were made on bright, sunshiny days, others on cloudy days, some few at night, etc. These variations in conditions under which tests were made open up many loopholes as to accuracy. As a result, only two categoric conclusions may be drawn as to the lighting here. The first is that a great deal of electricity is wasted and a great deal of poor lighting is produced because of the lack of servicing of electric fixtures. The second conclusion is that in many large areas of the plant the artificial lighting facilities furnished definitely are lower than is desirable in connection with the work performed.

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ILLUMINATION SURVEY

The advantages of good industrial illumination are many, the most important of which are reduction of accidents and the conservation of eyesight among workers.

Because of the nature of this report, it is impossible to present a complete discussion of the causes and effects of poor illumination or the advantages of good illumination. However, for the sake of clearness, some of the more common defects of illumination are very briefly discussed below in order that a better understanding may be had of the reasons surrounding the recommendations which will follow later in this section. These common defects are: quantity, quality (color), distribution, steadiness, diffusion and direction of light.

(a) When a worker is exposed to insufficient light, his working efficiency is reduced and his eyes are subjected to unnecessary strain, which, if continued over long periods of time, may result in permanent eye injury. Conversely too much light may result in glare which also may cause injury to workers eye.

(b) From the standpoint of quality (color), artificial illumination should approach daylight. In many industrial installations the artificial light is too yellow, which condition causes eyestrain. In many types of work, an adjustment of the color value of the light is desirable and in work places where color value judgements are to be made this becomes essential.

(c) Poor distribution of light is the result of uneven illumination throughout a work room. When this situation arises the workmen experience ocular fatigue which produces eyestrain and sets the stage for an accident.

(d) The harmful effects of unsteady illumination are obvious. Unsteady light produces eye fatigue because of the incessant demands upon the eye for readjustment. Other than from defective current, this condition may also be produced by smoke, dusts and mists from manufacturing processes.

(e) Diffusion and distribution of light are related, although good distribution can be attained without having good diffusion. Good distribution of light is the result of evenly spaced outlets carrying the same

wattage which eliminates dark areas from the work room. When it is necessary for the worker to look from a lighted area to a dark area during the course of work, a definite period of time is required for eye adjustment before he is able to see. A condition such as this sets a stage for an accident.

(f) Diffused light does not cast sharp, deep shadows which are the prolific cause of tripping accidents. Diffused illumination may be accomplished by having the light at a given point come from several sources. Reflections from ceiling, walls and manufacturing equipment are beneficial in obtaining this condition.

(g) The direction of light becomes important and sometimes dangerous under two conditions: (1) When reflection of light is directed into the eye and (2) when the concentrated source lies in the field of vision. Both of these conditions produce glare and are objectionable because they interfere with clear vision and increase the risk of accident; cause discomfort and eye fatigue; reduce efficiency; and if continued over long periods of time, may result in impairment of vision.

In order to improve any industrial lighting installation, the common defects mentioned above must be given careful consideration. It was with these defects in mind that the recommendations which follow later in this section for the improvement of the illumination in this plant were made.

The unit of quantity of illumination is the foot-candle and it is in this term that all measurements and requirements are specified. The instrument used in collecting this data was the Weston Foot-Candle Meter. In general all foot-candle measurements were made at the level of work and with the operator in position. Readings were not taken at all working places in the plants but wherever possible they were taken at various points to indicate the general condition in each workroom. Measurements were not only made at manufacturing processes, but also in offices, store rooms, packing departments, etc.

In addition to the foot-candle measurements, information such as evidence of glare, condition of present lighting equipment, color and condition of walls and ceilings and types of illumination equipment were

also noted. This information was used along with the foot-candle measurements in making the recommendations. The foot-candle measurements were compared with the standards set up by the Illuminating Engineering Society which appear as a booklet entitled "Code of Lighting." These standards were used as a basis for the recommendations, but due regard was given to the particular problems encountered in the plant.

The results of the survey indicate that in certain parts of the plant adequate illumination is being furnished. This is due in part to the more modern construction of the buildings and more recent installation of illumination equipment. On the other hand, many of the departments are found to have far from adequate lighting. The reasons for this involves a great many factors and may easily be referred back to the common defects of illumination which are listed above. In this connection it has been found that in some places the fixtures were of antiquated types and have outlived their usefulness. In other cases very little attempt has been made to maintain the lighting installation. In still other cases windows are dirty which prevent to a large extent the light from entering and walls, ceilings and equipment are a dark color which absorbs rather than reflects light. Good reflecting surfaces are very important in any lighting installation as a source of reflected light which aids in providing good distribution and diffusion.

In some instances it has been found that electrical outlets are plentiful but only a small number are equipped with lamps or reflectors. Also in certain instances lamps are being used without reflectors which is a waste of energy since the light is allowed to travel in all directions and a large percentage is absorbed by equipment and other dark surfaces. This practice has been found more especially in the storage and stock departments. Aside from the waste involved, this practice of using bare lamps results in glare, the harmful effects of which have been discussed above.

The proper and adequate maintenance of illumination equipment for both natural and artificial lighting is essential. Systems which were adequate when first installed soon deteriorate unless properly maintained. A definite schedule should be followed in cleaning all windows, lamps and

accessories and keeping the installations in proper adjustment and repair. In order that the highest efficiency may be obtained, walls and ceilings should be repainted light colors at regular intervals. Where dirt is allowed to collect on lamps and lighting fixtures, a considerable loss in illumination results. It has been proven repeatedly that inadequate maintenance of lighting fixtures will reduce the efficiency 50 per cent or more.

Since there is always the possibility that this plant will operate nights, and since a large percent of the days are cloudy, which aids very little in affording natural light, the lighting installation should be adequate to give required amounts of illumination at all times. At the times when illumination is sufficient without artificial light, they need not be operated. It was with this in mind that the recommendations were made. It will be found that in some cases recommendations were made to increase illumination even though the present light with the aid of natural light was sufficient. This was done in order to make the artificial illumination adequate without the aid of natural light.

Aside from the specific recommendations which are included under the "Field Data and Results" section, certain general recommendations now follow:

- (1) Wash walls and ceilings or paint walls and ceilings wherever feasible and repeat process at periodic intervals thereafter.
- (2) Wash all lighting fixtures in all offices and wash once each month thereafter.
- (3) Wash all other lighting fixtures and wash every three months thereafter.
- (4) Install approved reflectors or fixtures on all outlets which are not so equipped at present.
- (5) Replace those lamps which have had 1000 or more hours of service with new lamps and replace every 1000 hours of service thereafter.
- (6) Wash all windows and skylights and wash periodically thereafter.
- (7) Install new lamps in all unused outlets.

FIELD DATA AND RESULTS

Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	
Bldg. 244 - Tin Can Dept.					
2nd Floor - Machine Shop					
Bench	40	15-10	267	400	)
Lathes	50	15-10	333	500	)
	50	15-10	333	500	)
	40	15-10	267	400	)
	50	15-10	333	500	)
	50	15-10	333	500	)
	6	15-10	40	60	)
Shaper	20	15-10	133	200	)
Grinder	8	15-10	53	80	)
Drill Press	3	15-10	20	30	)
	10	15-10	67	100	)
Milling Machine	4	15-10	26.7	40	)
Grinder	18	15-10	120	189	)
	20	15-10	133	200	)
Screw Press	20	15-10	133	200	)
Drill Press	25	15-10	167	250	)
Pyrometer Gauges	8	15-10	53	80	)
Furnace	18	15-10	80	120	)
Grinder (tool)	3	15-10	20	30	)
Drawing Board	50%	15-10	333	500	)
Desk	50%	15-10	333	500	)
Hardness Tester	15	15-10	100	150	)
Lockers	10	6-4	167	250	)
Tool Cupboard	10	15-10	67	100	)
Sink Cupboard	4	10-6	40	67	)
Gauge Box	1	15-10	6.7	10	)
Lay Out Plate	5	15-10	33	50	)
Tin Can Dept. Store Room					
Desk	50%	15-10	333	500	)

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	
Scales	5	15-10	33	50	Install and app for all
Solder Bin	10	3-2	333	500	Install for all
Sp. Gr. Meas. Crock	5	15-10	33	50	Increase and inst reflect lamps.
Cupboard A	12	5-3	240	400	Install for all
Cupboard B	9	5-3	180	300	Same as
Cupboard	12	5-3	240	400	Same as
Lacing Machine	2	15-10	13.3	20	Install increase
Steel Rack	10	3-2	333	500	Install for all
A Bin West	50 1/2	5-3	1000	1667	)
A Bin East	0	5-3	0	0	) Install
B Bin West	13	5-3	260	433	) illumina
B Bin East	1	5-3	20	33	) storage
C Bin West	8	5-3	160	267	) approved
C Bin East	1	5-3	20	33	) bare lam
D Bin West	1	5-3	20	33	)
D Bin East	1	5-3	20	33	)
E Bin West	1	5-3	20	33	)
Tin Can Dept. Manufacturing					
Punch Press # 2	50	15-10	333	500	-----
Punch Press # 4	3	15-10	20	50	Install
Curling Machine	50 1/2	10-6	500 1/2	833 1/2	local 11

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Position	F. C. Reading	Standard	- % of Max. Std.	% of Min. Std.	Remarks
Doping Machine	30	10-6	300	500	-----
Doping Machine	25	10-6	250	416	-----
Handle Curling Machine	7	10-6	70	116	Increase v
Automatic Presses	30	15-10	200	300	-----
(north)	30	15-10	200	300	-----
(center)	20	15-10	133	200	-----
(center)	5	15-10	20	30	Install p
(center)	50%	15-10	333	500	local ill
(center)	50%	15-10	333	500	-----
(east)	50%	15-10	333	500	-----
(east)	10	15-10	67	100	-----
Slitting Machine	8	10-6	80	133	Increase v
	25	10-6	250	416	Increase v
	5	10-6	50	83	Increase v
Press Dept. Desk	35	10-6	350	583	-----
Punch Press (west)	5	15-10	33	50	)
(west)	35	15-10	233	350	)
(west)	35	15-10	233	350	)
(center)	20	15-10	133	200	) Increase
(north)	50%	15-10	333%	500%	) 100%.
(north)	50%	15-10	333%	500%	)
(north)	7	15-10	47	70	)
(center)	5	15-10	33	50	)
Doping Machine	50%	10-6	500%	833%	-----
Doping Machine (hand)	50%	10-6	500%	833%	-----
Doping Machine (north)	30	10-6	300	500	-----
(north)	15	10-6	150	250	-----
(north)	35	10-6	350	583	-----
Humming Machine	7	10-6	70	116	) Increase
Squeezer Machine	1	10-6	10	16	) near th
Seamer	1	10-6	10	16	)
Body Maker	3	10-6	30	50	)

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Reco
Side Seamer (south)	12	10-6	120	200	-----
(south)	2	10-6	20	33	Install
(south)	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{3}$	increas
Nozzle Sweater (south)	15	10-6	150	250	-----
(east)	5	10-6	50	83	) Increas
(south)	5	10-6	50	83	)
(south)	25	10-6	250	416	-----
Lar Water (south)	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{3}$	-----
(south)	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{3}$	-----
Lar Sweater	20	10-6	200	333	-----
	30	10-6	300	500	-----
Tester (south)	20	10-6	200	333	-----
(north)	30	10-6	300	500	-----
(north)	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{3}$	-----
(north)	10	10-6	100	166	-----
Sorting Bars (south)	12	10-6	120	200	-----
Slitter (north - 1st oper.)	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{3}$	-----
	12	10-6	120	200	-----
	3	10-6	30	50	Increas
Slitter (north-2nd oper.)	45	10-6	450	750	-----
	15	10-6	150	250	-----
Body Maker	50	10-6	500	833	-----
	10	10-6	100	166	-----
	20	10-6	200	333	-----
	18	10-6	180	300	-----
Seamer (center)	15	10-6	150	250	-----
	3	10-6	30	50	Install
	15	10-6	150	250	increas
	5	10-6	50	83	Increas
	10	10-6	100	166	-----
	20	10-6	200	333	-----
(north)	20	10-6	200	333	-----

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	
Flanger (center)	15	10-6	150	250	-----
	5	10-6	50	83	Incre
	10	10-6	100	166	Incre
	5	10-6	50	83	Incre
First Aid Room	50	15-10	333	500	-----
Locker Room	50	15-10	333	500	-----
Wash Room (men)	50	15-10	333	500	-----
Wash Room (women)	50	15-10	333	500	-----
Tin Can Department - 1st Floor					
Packing Cans - Line 1	50	10-6	500	833	Insta
Line 2	5	10-6	50	83	)
Line 3	5	10-6	50	83	) Incre
Line 4	7	10-6	70	116	) insta
Line 5	3	10-6	30	50	)
Line 6	0	10-6	0	0	)
Foreman's Office	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{2}$	-----
Carton Repairing	50 $\frac{1}{2}$	10-6	500 $\frac{1}{2}$	833 $\frac{1}{2}$	-----
Warehouse	3	3-2	100	150	-----
Tin Can Department - Basement					
Aisle	0	3-2	0	0	) Insta
Corner	7	3-2	23	35	) refle
Aisle	0	3-2	0	0	) outle
Stairway	2	3-2	67	100	Incre
Boil Machine (north)	10	10-6	100	166	) Incre
Clerk's Desk (north)	7	10-6	70	116	)
Shop (N. E. corner)	4	10-6	40	66	)
Lunchroom	50 $\frac{1}{2}$	15-10	333	500	-----
Women's Rest Room	50 $\frac{1}{2}$	15-10	333	500	-----
Tin Can Department - Office					
Multigraph	12	15-10	80	120	)
Mimeograph	10	15-10	67	100	) Incre
Desk	10	15-10	67	100	) 75%.
REDACTED Desk	3	15-10	20	30	) a whi
					color

0007-SWP-000030541

Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendation
Mail Sorting	3	15-10	20	30	) Increase
Stamping	5	15-10	33	50	) 75% Pair
Mail Scales	5	15-10	33	50	) ceiling a
Stock Shelves	2	8-5	25	40	) off white
Files	4	15-10	27	40	)
Sorting Table	5	15-10	33	50	)
Work Table	10	15-10	67	100	)
Factory Office	12	15-10	80	120	-----
	7	15-10	47	70	Increase
REDACTED	15	15-10	100	150	-----
	7	15-10	47	70	Increase
	6	15-10	40	60	Increase
	8	15-10	53	80	Increase
	10	15-10	67	100	-----
	8	15-10	53	80	Increase
	15	15-10	100	150	-----
	10	15-10	67	100	-----
	5	15-10	33	50	Increase
	10	15-10	67	100	-----
	9	15-10	60	90	Increase
Vault	9	15-10	60	90	Install a approved
Stair Landing	11	3-2	370	550	-----
Information Window	7	15-10	47	70	)
	7	15-10	47	70	) Install a
	15	15-10	100	150	) obtain eq
	15	15-10	100	150	) of light.
	10	15-10	67	100	) blinds to
	25	15-10	167	250	) natural s
	50	15-10	333	500	)
Addressograph	2	15-10	13	20	)
Ditto Machine	1	15-10	7	10	)
Vestibule	0	3-2	0	0	) Install a increase

0007-SWP-000030542

Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recom
General Office	3	15-10	20	30	)
	3	15-10	20	30	)
REDACTED	4	15-10	27	40	) Increase
	4	15-10	27	40	) by 100%
	4	15-10	27	40	)
	4	15-10	27	40	)
	6	15-10	40	60	)
	3	15-10	20	30	)
	12	15-10	80	100	)
	10	15-10	67	100	)
	15	15-10	100	150	)
File Closet	25	15-10	167	250	)
Western District Sales Office	45	15-10	300	450	)
	10	15-10	67	100	)
	7	15-10	43	70	)
	5	15-10	33	50	)
	7	15-10	47	70	)
	8	15-10	53	80	)
	5	15-10	33	50	) Increase
	5	15-10	33	50	) 100%.
	6	15-10	40	60	)
	2	15-10	13	20	)
	3	15-10	20	30	)
	18	15-10	120	180	)
	50 1/2	15-10	333 1/2	500 1/2	)
	50 1/2	15-10	333 1/2	500 1/2	)
	35	15-10	230	350	)
	10	15-10	67	100	)
	50 1/2	15-10	333 1/2	500 1/2	)
	10	15-10	67	100	)
	40	15-10	260	400	)
	10	15-10	67	100	)
	12	15-10	80	120	)

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Re
REDACTED	10	15-10	67	100	-----
	20	15-10	133	200	-----
Main Entrance	15	5-3	300	500	-----
Main Stair	0	3-2	0	0	Increase w
Vault Table	4	15-10	26	40	) Install ad
Vault Files	3	15-10	20	30	) and increa
Billins Dept.					-----
	25	15-10	167	250	-----
	10	15-10	67	100	Increase w
Order Entry Machine	6	15-10	40	60	Increase w
	7	15-10	47	70	Increase w
	4	15-10	26	40	) Install ad
Order Entry Machine	4	15-10	26	40	) and increa
Medical Dept.					-----
Dr. Hess' Desk	10	15-10	67	100	Increase w
Nurse's Desk	6	15-10	40	60	Install ap
					desk lamp.
Ex. Room	50%	15-10	333%	500%	-----
Employment Dept.					-----
Desk	25	15-10	167	250	-----
Desk	45	15-10	300	450	-----
Counter	5	15-10	33	50	Increase w
Reception Room Desk	5	15-10	33	50	Increase w
Reception Room Desk	12	15-10	80	120	-----
	50%	15-10	333%	500%	-----
Allied Research Laboratories					-----
3rd Floor					-----
Conf. Room	50%	10-8	500%	625%	-----
	50%	10-8	500%	625%	-----
Random Positions over Floor	8	10-8	80	100	Increase g
					25% to 50%

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendations
2nd Floor					
Lay Out Table	15	15-10	100	150	)
Lab. Bench	5	15-10	33	50	)
Balance Corner	6	15-10	40	60	)
Dry Rack Bench	15	15-10	100	150	)
Hood	10	15-10	67	100	)
Desk	12	15-10	80	120	)
Bench (west)	5	15-10	33	50	)
Balance	10	15-10	67	100	)
Roll Mill	50%	15-10	333%	500%	)
Wash Tubs	10	15-10	67	100	)
Shelves	0	15-10	0	0	)
Director's Desk	50%	15-10	333%	500%	)
Lunch Room Tables	4	15-10	26	40	)
Kitchen	50%	12-8	416	625	)
1st Floor					
Time Cards	2	10-6	20	33	)
Time Clocks	2	10-6	20	33	)
Information Booth	50%	10-6	500%	333%	)
Bulletin Board	15	10-6	150	250	)
Basement AR Bldg. (531)					
Paint Room	15	15-10	100	150	)
Work Room Bench	15	15-10	100	150	)
Centrifuge Ganges	2	15-10	13	20	)
Formulation Lab. Bench	1	15-10	7	10	)
	15	15-10	100	150	)
Oven Temp. Table	1	15-10	7	20	)
Roll Mill	3	10-6	30	50	)
Batch Table	6	10-6	60	100	)
Washing Table	6	10-6	60	100	)
Scales	1	15-10	7	10	)

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Position	P. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendation
Files	7	15-10	47	70	Increase wattage and
Locker Room Floor	1	6-4	17	25	Install out
					wattage and
					lamps.
					Install from
Bldg. 110 - Coal Tar Labs.	6	6-4	100	150	
Bench	3	15-10	20	30	)
Desk	5	15-10	33	50	)
Balance	5	15-10	33	50	)
Burettes	3	15-10	20	30	)
Bldg. 110 - Pulp Labs.					
Desk	5	15-10	33	50	)
Color Block	5	15-10	33	50	)
(at window)	50%	15-10	333%	500%	)
Analytical Balance	5	15-10	33	50	)
Balance	7	15-10	47	70	)
Sink	5	10-6	50	82	)
Moisture Balance	3	15-10	20	30	)
Bldg. 110 - Dry Color Office					
Desk - Secretary	50%	15-10	333%	500%	)
Desk - Chemist	20	15-10	133	200	)
	30	15-10	200	300	)
Analytical Balance	50%	15-10	333%	500%	)
	40	15-10	260	400	)
Rubbing Slabs (at window)	50%	15-10	333%	500%	)
(1st row)	20	15-10	133	200	)
Analytical Balance	10	15-10	67	100	)
	6	15-10	40	70	)
Rubbing Stones (2nd row)	7	15-10	47	70	)
Analytical Balance	5	15-10	33	50	)
Mixing Bench	2	15-10	12	20	)
Sink	4	10-6	40	67	)
Desk	7	15-10	47	70	)
	10	15-10	67	100	)

0007-SWP-000030546

Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendation
Sink	2	10-6	20	33	) It is under is to be made soon. For specific r made.
Gauge in N. E. Corner	4	15-10	27	40	
Bldg. 20 - Spray Room Gauges	10	15-10	67	100	Increase v
Black Ash Plant					
Rotary Runway	2	5-3	66	100	) Equip all high watt fixtures f obtain equ illuminati outlets at candle val
Hauling - Hopper	0	5-3	0	0	
Leecher Ladders	0	3-2	0	0	
Filter Press	8	6-4	133	200	
Ore Crusher	0	3-2	0	0	
Feeder	20	3-2	667	1000	
Ore Hauling	2	3-2	66.7	100	
Ore Weighing	20	15-10	133.3	200	
Lithopone Plant - 1st floor					
Colored Washroom	2	6-4	33	50	Increase v
White Washroom	5	6-4	83	125	-----
Zinc Sulfate Tubs	2	8-5	25	40	Install ov
Pumps	2	3-2	66	100	approved r
Filter Presses	0	6-4	0	0	-----
Test Bench	3	15-10	20	30	Install ov
Stairway	0	3-2	0	0	approved r
Scales	12	15-10	80	120	Increase v
Scales (set)	1	5-3	20	33	-----
Roll Mill	2	5-3	40	67	) Install ov
Pulper Scales	2	10-6	20	33	
Bulk Scales	2	10-6	20	33	) approved r
Desk	36	15-10	230	350	
Filter Cloth Room	9	5-3	180	300	-----

0007-SWP-000030547

Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Reco
Millwright's Shop Bench	3	10-6	30	50	)
Middle of Floor	2	5-3	40	67	) Instal
Settling Tank Top	1	5-3	20	33	) with a
Rag Pile	0	5-3	0	0	)
Locker Room (foreman's)					
Stencilling Machine	18	15-10	120	180	) Instal
First Aid Cabinet	1	15-10	7	10	) Increa
					Aid Ca
Starting Switch	1	5-3	20	33	)
Time Clock	2	15-10	13	20	) Instal
Time Cards	1	15-10	7	10	) approv
Lithopone Office	40	15-10	267	400	-----
Plumbing Shop Bench	17	10-6	170	280	) Instal
Lithopone Plant - 2nd floor					
Main Stairway	50	3-2	1667	2500	Instal
Packer Hopper	1	5-3	20	33	Instal
					approv
"Blue" Scales	5	10-6	50	83	Increa
Main Stairway	4	3-2	133	200	-----
Lithopone Plant - 3rd floor.					
Strike Tubs	2	5-3	40	66.7	Increa
					instal
Test Bench - Color	8	15-10	53	80	Increa
Record Board Charts	3	15-10	20	30	Increa
					instal
Filter Presses	20	5-3	400	666	-----
Beam Scale	50	10-6	500	833	-----
Blackboard	30	10-8	300	375	-----
Motor Starters	2	5-3	40	66.7	-----
Pulping Scale	10	15-10	66	100	-----
	15	15-10	100	150	-----
Blackboard	6	10-6	60	100	-----
Rotary Feeder	10	6-4	167	250	-----

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Position	P. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Re
Strike Tub Scales (rough)	2	10-6	20	33	Insta
Equalizer	2	5-3	40	67	appro
No. 5 Tub Stair	1	5-3	20	33	Insta
No. 5 Tub Stair	1	5-3	20	33	Insta
Cadmium Plant					
Gauges	1	15-10	6.7	10	Insta
Furnace	2	5-3	40	67	appro
Tubs	0	5-3	0	0	Insta
Press Gauge	5	15-10	33	50	incre
Test Bench	0	15-10	0	0	100%
Sludge Scale	25	15-10	167	250	Insta
Zinc Dust Scale	4	15-10	26.7	40	appro
Bldgs. 18 and 20 - P. & V. Testing Labs.					incre
Analytical Balance	7	15-10	47	70	-----
Hubbing Slab	20	15-10	133	200	-----
Test Bench	10	15-10	67	100	-----
Files	12	15-10	80	120	-----
Bldg. 513 - C. P. Labs.					
Library Table	35	15-10	233	350	-----
Side Lab. No. 1					
Bench	13	15-10	76	130	-----
Desk	50 1/2	15-10	333 1/2	500 1/2	-----
Hood	12	10-6	120	200	-----
General Lab.					
East Side					
Analytical Balance	7	15-10	47	70	Insta
	15	15-10	100	150	lamps
Chemical Bench	4	15-10	27	40	incre
Burettes	30	15-10	200	300	-----

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recon
Desk -	5	15-10	33	50	) Increase
Bench REDACTED	5	15-10	33	50	
Desk	50 1/2	15-10	333 1/2	500 1/2	-----
Desk -	20	15-10	133	200	-----
Desk -	8	15-10	53	80	Increase by 50% -----
Desk -	20	15-10	133	200	-----
Department Office					
Desk -	40	15-10	233	400	-----
Desk -	40	15-10	233	400	-----
Desk -	25	15-10	167	250	-----
Desk -	10	15-10	67	100	-----
North Side Benches					
Color Slab	30	15-10	200	300	-----
Analytical Balance	25	15-10	167	250	-----
Standard Desk	8	15-10	53	80	Increase -----
West Side Benches					
Burettes	35	15-10	233	350	-----
Bldg. 512 - Lacquer Raw Materials Testing Lab.					
Desk -	35	15-10	233	350	-----
Analytical Balance	15	15-10	100	150	-----
Desk	35	15-10	233	350	-----
Bench	10	15-10	67	100	-----
Benches - Inner Wall	10	15-10	67	100	-----
- At Windows	12	15-10	80	120	-----
Hood	8	10-6	80	133	-----
Sample Files	2	15-10	13	20	Increase in area -----
Bldg. 512 - Lacquer Mach. Room					
Oil Bath	12	15-10	80	120	-----
Rheostat	10	15-10	67	100	-----
Bldg. 547 - Technical Service Lab.					
Desk -	30	15-10	200	300	-----

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommend
Desk -	25	15-10	167	250	-----
Bench - North	15	15-10	100	150	-----
Spray Booth	30	15-10	200	300	-----
Analytical Balance	4	15-10	27	40	Install
Middle Bench	3	15-10	20	30	Increase
					area to
					outlets.
Desk - REDACTED	10	15-10	67	100	-----
Bldg. 547 - Lacquer Dept. Labs.					
Desk -	35	15-10	233	350	-----
Desk -	25	15-10	167	250	-----
Desk -	25	15-10	167	250	-----
Desk -	25	15-10	167	250	-----
Desk -	50/	15-10	333/	500/	-----
Bench - Outer Row	10	15-10	67	100	)
Bench - Inner Row	8	15-10	53	80	) Increase
Desk -	7	15-10	47	70	) Install
Desk -	7	15-10	47	70	) Engineer
					Lamps.
Automobile Section					
Desk -	50/	15-10	333/	500/	-----
Desk -	7	15-10	47	70	Install
					Engineer
					Lamp.
Lay Out Bench	50/	15-10	333/	500/	-----
Formulative Bench	50/	15-10	333/	500/	-----
Desk -	10	15-10	67	100	-----
Display Room	50/	15-10	333/	500/	Replace
					frosted
Furniture Technical Service Lab.					
Window Benches	50/	15-10	333/	500/	)
North Balance	40	15-10	267	400	) Replace
Conf. Table	15	15-10	100	150	) frosted
Desk -	13	15-10	87	130	) already
Desk -	10	15-10	67	100	)

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommend
Bldg. 528 - Poshain Lab.					
Balance - East	7	15-10	47	70	) Install m
Color Bench	30	15-10	200	300	) row of ba
Desks	10	15-10	67	100	) with fro
Analytical Balance - West	15	15-10	100	150	) fixtures.
White Lead Dept.					
Stacks - O.D.P.					
Melting Pot	4	10-6	40	67	Install o
Pig Lead Storage	3	3-2	100	150	
Casting Machine	1	10-6	10	17	Install o
Buckle Piles	0	3-2	0	0	Install o
					equip wit
Casting Pit	4	3-2	133	200	
Desk - Clerk	0	15-10	0	0	) Install o
Scale Beam	0	15-10	0	0	) equip wit
Upper Level Walk	0	3-2	0	0	Increase
					by instal
Yield Scale	1	15-10	7	10	Install o
					approved
Foreman's Office	15	15-10	100	150	
Conveyor Cat Walk	15	3-2	500	750	
White Lead Mills					
Wash Room at Fountain	3	6-4	50	75	Increase
Locker Room	0	6-4	0	0	) Increase
Acetic Acid Storage	0	3-2	0	0	) for thos
Oil Scales	5	15-10	33	50	Install o
					approved
Lab.					
Bench	5	15-10	33	50	) Install o
Scales	3	15-10	20	30	) approved
Burettes	25	15-10	167	250	
Balance	8	15-10	53	80	Install a
Analytical Balance	15	15-10	100	150	
Desk	10	15-10	67	100	

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendati
Thermometer Recorders	0	15-10	0	0	) Install additi
Pulper Scales					) and equip with
West	0	15-10	0	0	) reflectors. I
Middle	3	15-10	20	30	) resulting watt
East	1	15-10	7	10	)
Pulper Desk	4	15-10	27	40	)
Oil Scale - East	2	15-10	13	20	)
West	4	15-10	27	40	)
Consumption Gauges	2	15-10	13	20	)
Office					
Desk -	50%	15-10	333%	500%	-----
Desk - REDACTED	15	15-10	100	150	-----
Desk -	20	15-10	133	200	-----
Desk -	50%	15-10	333%	500%	-----
Desk -	50%	15-10	333%	500%	-----
Desk -	15	15-10	100	150	-----
Typewriter	15	15-10	100	150	-----
O. D. Water Mills					
Tool Grindstone	5	15-10	33	50	) Increase watta
Stone Dressing	2	15-10	13	20	) for outlets an
Packing Desk	6	10-6	60	100	) reflectors.
White Lead Scale	0	15-10	0	0	) Increase watta
Label Pasting	2	10-6	20	33	) Install outlet
Packing Scale	0	15-10	0	0	) reflector - in
BW 103 Thinning Scale					) wattage by 50%
Pulper No. 1	0	15-10	0	0	)
Pulper No. 2	0	15-10	0	0	)
Red Lead Mill - 2nd floor					
Carbonate Scale	0	10-6	0	0	) Install outlet
Red Lead Scale	1	10-6	10	13	) reflectors and
					) to meet requir

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recom
Bldg. 15-4 - Label Stock Room					
Aisle - Middle	0	3-2	0	0	Increase
- Side	50%	3-2	-	-	most rec
Label Printing Press	50%	15-10	333%	500%	-----
Label Stock Desk	50%	15-10	333%	500%	-----
Bldg. 12 A 3					
Leaker Bench	2	10-6	20	35	Install
Aisle - Middle	0	3-2	0	0	approved
- Outer	2	3-2	67	100	Increase
Bldg. 13-3					most rec
Packing	1	10-6	10	17	-----
Sealing Desk	2	15-10	13	20	) Install
Foreman's Desk	50%	15-10	333%	500%	) with ap
Bin Stock - Middle	4	8-5	50	80	Rearrang
Parcel Post Desk	10	15-10	67	100	Increase
Brush Room	0	8-5	0	0	-----
Offices - Stock Dept.					Install
Desk -	10	15-10	67	100	approved
Desk - : REDACTED	15	15-10	100	150	)
Desk - :	8	15-10	53	80	) Illumin
Desk - Special Order	12	15-10	80	120	) this pe
	10	15-10	67	100	) of natu
Desk - Stock Clerk	40	15-10	267	400	) good li
Auxiliary	5	10-6	50	83	) increas
Desk - Out. Mail	10	10-6	100	166	) 50%.
Typist - Inner Wall	10	15-10	67	100	)
	7	15-10	47	70	)
Filing Room	4	15-10	27	40	)

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Position	V. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendations
Bldg. 14-1 Carload Shipping Room	0	6-4	0	0	Install outlet general wattage requirements tion.
Office	10	15-10	67	100	-----
Bldg. 13-1					
ICL Dept. Aisle	1	3-2	33	50	Increase wattage
Pick Off Point	0	8-5	0	0	Install outlet with approved Increase general wattage required Install approved Engineering 3 Lamp.
Shipping Office Desk	2	15-10	13	20	-----
Bldg. 12 A 1					
Finishing - Middle Aisle	11	3-2	33	50	Increase wattage
Labeling	1	10-6	10	16	Install outlet approved refl.
Foreman's Desk	30	15-10	200	300	-----
Barrel Finishing	0	8-5	0	0	Install outlet approved refl.
Desk	30	15-10	200	300	-----
Bldg. 513-3					
Desk - REDACTED	15	15-10	100	150	-----
Desk -	50	15-10	333	500	-----
Aisle - Middle	0	3-2	0	0	Increase general
Bldg. 512-3					
Packing Lines	8	10-6	80	133	-----
Scales	0	15-10	0	0	) Install additional
Desk	3	15-10	20	30	) and equip with
Stencil	6	15-10	40	60	) Increase general
Label Line	4	10-6	40	66	)

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendations
Parcel Post Scales	1	15-10	7	10	) Install outlet with approved Increase gen. most required
Scales	2	15-10	13	20	
Bldg. 547-1					
Stock Aisles	1	3-2	33	50	Increase wattage
Desk	12	15-10	80	120	
Paint Dept.					
Bldg. 19 - Basement					
Filling Machine	5	10-6	50	83	Increase wattage
Ball Mill Air Gauge	6	10-6	60	100	
Bldg. 19-1					
Balance Scales	4	10-6	40	66	Increase wattage
Electric Motors	20	10-6	200	333	
Tank Mixer Scale	15	10-6	150	250	
A Dept. Office Desk	45	10-6	450	750	
C Dept. Office Desk	10	10-6	100	166	
Bldg. 19-2					
C. Dept.					
Mill Floor Scales	5	10-6	50	83	Increase wattage
Roll Mill	10	10-6	100	167	
D. Dept.					
Desk	10	15-10	67	100	
Aisle	50	10-6	333	500	
Filling Machine - Lower Level	10	10-6	100	167	
Desk	13	15-10	87	130	
Bldg. 23-3					
Shading Bench	50	15-10	333	500	
F. Dept. Office	50	15-10	333	500	

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendation
Bldg. 23-2					
Filling Floor Scales	5	10-6	50	83	Install on approved
Filling Machine	10	10-6	100	167	-----
Desk	7	15-10	47	70	Install on approved
Bldg. 23-1					
Pebble Mill Scale	6	10-6	60	100	) Increase
Packing Line	2	10-6	20	33	) 75%.
Bldg. 18-1					
Filling Floor Desk - South	1	15-10	7	10	Install on approved
Scales - South	25	15-10	167	250	-----
Platform Scales - Middle of Floor	2	10-6	20	33	Install on approved
Desk	30	15-10	200	300	-----
Packing & Labelling	5	15-10	30	50	) Increase
Shading Gallery	8	15-10	53	80	) by 100%.
Desk - North	2	15-10	13	20	) -----
Stamping Machine	10	15-10	67	100	-----
Bldg. 17-3					
Desk	15	15-10	100	150	Install on lamps.
Scoop Scales	0	10-6	0	0	) Install on
Platform Scales	2	10-6	20	33	) approved
Platform Scales - Large	2	10-6	20	33	) general w reflector
B Dept. Office	20	15-10	133	200	-----
Testing Scales	10	10-6	67	100	-----
B Dept. Grinding Floor Desk	10	15-10	67	100	-----

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Position	P. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendation
Stain Dept.					
H. Dept. Office	25	15-10	167	250	-----
Bldg. 11 - Stain Mfg.					
Filling Machine	5	10-6	80	83	Increase
Mixing Floor Aisle	2	3-2	66	100	-----
Desk	3	15-10	20	30	Install & approved
Bldg. 9 - H. Dept.					
Scales	2	10-6	20	33	) Install
Filling Points	1	10-6	10	17	) with app
Bldg. 58 - Varnish Dept.					
3rd floor.					
Mid. Point	3	10-6	30	50	Increase
Beam Scales - West	15	10-6	150	250	-----
East	3	10-6	30	50	) Install
Small	5	10-6	50	83	) approved
2nd floor.					
Aisles - Mid. Point	2	3-2	66	100	-----
1st floor.					
Loading Scales	30	10-6	300	500	-----
Washroom	10	6-4	167	250	-----
	2	6-4	33	50	Increase
Bldg. 59 - 1st floor.					
Cooling Hood Therm.	1	10-6	7	10	) Install
Storage and Weighing Room Scales	0	10-6	0	0	) approved
general					general
Fire Room					
North Scale	13	10-6	87	130	-----
South Scale	5	10-6	33	50	Increase
Varnish Office	20	15-10	133	200	-----
REDACTED	20	15-10	133	200	-----
	20	15-10	133	200	-----

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommend
Testing Table	6	15-10	40	60	Increase
Bldg. 56 Pump Room Scales	1	10-6	18	16	Install o approved
Bldg. 57 Thinning Room Gauges	15	15-10	100	150	-----
Bldg. 56 Filter Press Room Desk	50 1/2	15-10	333 1/2	500 1/2	-----
Gauge	10	15-10	67	100	-----
Bldg. 42 Blowing Room	1	10-6	19	16	Install o approved
Bldg. 41 Blowing Room Recorders	5	15-10	33	50	Install r
Bldg. 53 - Varnish Filling Desk	8	15-10	53	80	Increase
West Scales	15	10-6	150	250	-----
Power Plant Desk	0	15-10	0	0	) Install s
Instrument Board	0	10-6	0	0	) equip wit
Switchboard	0	10-6	0	0	) wattage t
Alarm Board	0	10-6	0	0	) illuminat
Steam Pumps	4	8-5	50	80	Install f reflector available
Boiler Room Stoker No. 1 Instrument Board	3 0	5-3 10-6	60 0	100 0	) Install s) lamps wit
Aisle	0	3-2	0	0	) Increase
Sprinkler Gauges	0	10-6	0	0	)
Chemical Products Division Bldg. 501 Beta Plant Gallery Rail	10	10-6	100	167	-----

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendation
Foreman's Desk	15	15-10	100	150	Install
Autoclave Gauge	0	10-6	0	0	Install with app
Bldg. 501-2					
Thermometer	0	10-6	0	0	) Install
Beam Scales	1	10-6	10	16	) approved
Recorders	15	10-6	150	250	
	6	10-6	60	100	Increase
Bldg. 501-1					
Desk	30	15-10	200	300	
Beam Scales	0	10-6	0	0	Install approved
Bldg. 504-1 Azo Dye Dept.					
Beam Scales	6	10-6	60	100	
Recorders	50 1/2	15-10	333 1/2	500 1/2	Install
Barrel Filling Aisle	1	5-3	20	33	Increase
Bldg. 504-2					
Sulfonation Thermometer	1	10-6	10	16	) Install
Recorder	20	10-6	200	333	) approved
Desk	2	15-10	13	20	) Install
Beam Scales	8	10-6	80	133	) approved
Coupling Tub	7	10-6	70	117	
Desk	6	15-10	40	60	Increase Install
Bldg. 504-3					
Beam Scales	0	10-6	0	0	Install approved
Ice Loading	3	5-3	60	100	
Bldg. 506-2					
Desk	30	15-10	200	300	

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Rec
Bldg. 506-1 Desk	1	15-10	7	10	Install approved
Foreman's Office	50%	15-10	333%	500%	-----
Bldg. 502 Foreman's Desk	35	15-10	233	350	-----
Recorders	50%	15-10	333%	500%	Install
Bldg. 504-3 - Tobias Acid Plant Foreman's Desk	15	15-10	100	150	-----
Bldg. 511-3 Beam Scales	3	10-6	30	50	Increase
Bldg. 514-3 Beam Scale	0	10-6	0	0	) Install) approved
Bldg. 511-2 Sulfonation Gauge	0	10-6	0	0	) Install) approved
Bldg. 514-1 Beam Scale	0	10-6	0	0	Install approved frosted lamps.
Bldg. 528 - Fuchsia Dept. Beam Scale	10	10-6	100	166	-----
Aisle	1	3-2	33	50	Increase Substitu clear gl
Bldg. 516-1 Beam Scale	1	10-6	10	16	Install approved
Gallery Tub	3	5-3	60	100	-----

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Position	P. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recommendations
Bldg. 114-1 Beam Scale	0	10-6	0	0	Install from approved ref existing out
Shipping Desk	10	15-10	67	100	-----
Bldg. 114-2 Blending	5	15-10	33	50	Increase wat
Bldg. 113-2 Blending Floor Desk	0	15-10	0	0	Install outl approved ref
Bldg. 112-2 Aisle	0	3-2	0	0	Increase gen
Striker Tub	0	6-4	0	0	Install outl approved ref
Bldg. 111-3 Striking Floor Desk	10 30	6-4 10-8	167 300	250 375	-----
Bldg. 112-3 Striking Floor Scale Desk	3 5	10-6 15-10	30 33	50 50	) Install outle) with approved
Bldg. 130-3 Striking Floor	10	6-4	167	250	-----
Bldg. 111-4 Sodium Acetate Tank	4	3-2	133	200	-----
Lead Scale	35	10-6	350	583	Install appr
Chromate Scale	8	10-6	88	133	-----

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Position	F. C. Reading	Standard	% of Max. Std.	% of Min. Std.	Recomm
Coal Tar Plant					
Bldg. 451					
Desk	50 $\frac{1}{2}$	15-10	333 $\frac{1}{2}$	500 $\frac{1}{2}$	-----
Can Filling	10	10-6	100	167	-----
Bldg. 475					
Labelling	1	10-6	10	17	Install c
Can Filling	5	10-6	50	83	approved Increase v
Bldg. 452					
Scales	3	10-6	30	50	Increase v
Bldg. 450					
Scales	15	10-6	150	250	-----

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COMMENT AND RECOMMENDATIONS ON THE TIN CAN PLANT

Various sections of this report include items of data based upon investigations of the Tin Can operations. Consideration of the sum total of information leads to the following summary and recommendations:

1) Soldering, both of automatic and hand types, characterizes much of the work of this department. This solder is believed to represent a mixture of lead and tin. By actual tests of the atmosphere, considerable quantities of lead have been found and definitely more than the minimum required to produce lead poisoning, provided exposure exists. This lead foremostly arises in the form of fume from soldering operations. To a slight extent, lead is contributed in the form of the black oxide off ofterne plate. The exact quantities of lead present may be found in that other section of this report devoted to "lead analyses". It is recalled that the maximum in the Tin Can Plant is just above 11 milligrams of lead per ten cubic meters of air. This represents about 7 times the minimum quantity accepted as the daily intake of lead sufficient to product lead poisoning in some persons.

Not only is lead present in the air, but a few workers are showing minimal signs of lead absorption. Even though no case of lead poisoning may have arisen over a period of years, it is no less within reason to believe that at any time one or more cases might arise. It is therefore recommended that such steps be taken as will maintain the lead content of the atmosphere at a maximum of 1.5 milligrams of lead per ten cubic meters of air. This may be accomplished by the following steps:

a) It is noted that thermostats have been installed on all automatic machines. These thermostats should be set so as to maintain the lowest possible temperatures compatible with the requirements of the operation. If the temperature may be held at about 550-575 degrees, very little lead fume will be produced. It is frequently true that operations of this character make use of temperatures from 100-200 degrees higher than necessary, and thus waste both fuel and lead.

b) The hoods about most machines in this department are of poor design or rather are poorly located. Most hoods are so high above the operation involved that fume is not entrained and may be seen visibly



Automatic Soldering of Paint Containers.
Note Extensive Hooding for Protection
Above Molten Solder Container

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to pass out into the room instead of upward into the hood.

c) Insufficient air is being pulled through the exhaust system for purposes of evacuating lead fume. Although this system makes use of mechanical devices for air movement, the system is either overloaded or at least is otherwise deficient. At least double the quantity of air now moved through this system should be provided. The exhaust system in the small room in which ear lugs are soldered depends for fume evacuation only on stack action. This portion of the operation should either be provided with a motorized exhaust system, or else should be made a portion of the main room system, but without overloading that system.

d) Remarks made about the extensive height of hoods are especially directed to small automatic operations such as the isolated room where ear lugs are soldered, along with certain other soldering operations.

e) On various trips made into this plant, it has been observed that hand soldering is carried out at different points not all of which are likely to be in operation at any one time. Certain of this hand work may be regarded as semi-automatic, in that certain machine devices facilitate hand work. Since at least one hand solderer is showing minimal signs of lead absorption, it seems desirable to recommend that hoods be constructed and operated over major hand operations. It is probable that these hoods may be included in the one motorized system above specified as desirable.

f) At some subsequent time, additional lead analyses should be made in order to make sure that the standards set have been attained and are being maintained.

g) It is possible, but not proved, at the time of the writing of this section, that some lead is being carried to the Tin Can Department on certain days from nearby portions of the plant devoted to lead manufacture. This is being investigated and if found to be a fact, plans will be made for remedying this in connection with these other departments.

2) In this department, the real hazard is not one of lead, but that of noise. Of all large scale operations in the plant, this department stands out as a noise maker. Naturally, this is a consequence of the handling of metal (sheet) and hollow shapes made out of sheet metal.

However, some noise in this department is created by overhead drives, stamping and slitting machines, punch presses, etc.

Few persons exposed to noise are fully conversant with the ill effects produced. It is to be said that there is so much noise in this department that in the course of several years, a fair percentage of workers would become hard of hearing and all continually are victims of minor nervous disorders, excessive fatigue, irritability, resulting from the continuous din of noise. It is not necessary to make noise measurements and to record in decibels the excess noise over desirable states of quietude. However, it would be desirable to make use of audiometers or other hearing measuring devices in the belief that at the present time at least 20% of all persons employed will now show some degree of hearing deficiency. The remedy for this situation is not easy and if achieved at all will represent a large and perhaps unwarranted outlay of money. Consideration should be given to the following points:

a) The most troublesome of the noises produced by machine operation is that from the double action ring dye stamping machines, three of which are present on this second floor. Of these the one located above the department office causes the most vibration in the entire building. This machine is not in use at all times, which is fortunate. The fact that it is located just above the department office is significant in that office workers are subject to a disturbing variety of noise and vibration. Even though these office workers should maintain that they have become accustomed to this noise, the injury goes on no less.

b) A fair amount of noise is produced by worn bearings and unnecessary play in moving parts. It will require no great amount of ingenuity, skill or money to rectify some of these numerous petty noise makers.

c) The great bulk of the high pitched noise arises from the clash of metal on metal, such as the vertical dropping of units in the process of manufacture. It is recommended that an engineer be assigned the duty of modifying all possibly noisy processes through the introduction of rubber track wherever practical, the elimination of direct dropping of metal on metal through the introduction of rubber baffles, etc.

d) About one-third of the machines in this department are now mounted on rubber. The remainder to good advantage might be so mounted. Some of the distinct sources of noise arise in machines not rubber mounted. Also it conceivably might be practical to build up noise deadening walls and ceilings. Again this is left to engineers. In short, without unfavorable criticism of any person or persons and without pretending that a full remedy has been found, it is here pointed out that much may be gained in this department through efforts to eliminate a great deal of the noise now present.

5) During the course of this investigation, frequent comment has been made that the workers in the Tin Can Department are unlike in their responses any other division of the work force. For example, among other items, it has been pointed out that these workers are continually complaining about the quality of food and that they make unusual and extraordinary demands for special foods. Without regarding this situation very highly, it may be related that this general state of irritation, irritability, proneness to complain and general dissatisfaction is the customary emotional state among workers continually exposed to noise. This comment is made in order to tie in the preceding section with the well known situation that the Tin Can workers comprise a jittery and frequently upset portion of the work force.

COMMENT AND RECOMMENDATIONS FOR LITHOPONE MANUFACTURE

In dealing with lithopone, it is fortunately true that the major ingredients are substantially non-toxic. For years lithopone has been promoted as a non-toxic substitute for lead paint coatings. However, the situation in any plant and particularly in this plant, is not so freed of concern as might be desired. The zinc component of lithopone starts not with zinc sulphide, but with zinc sulfate and in an impure state, calling for extensive treatment. Likewise the tift ore of the barium component is highly impure and calls for extensive chemical modifications. Out of these requirements and in the further manufacture of lithopone, a number of situations here exist leading to recommendations.

1) The dust of zinc sulfate is distinctly irritating to the mucous membranes of the respiratory tract and will lead to septal perforation. One or more persons now employed present nasal perforation, presumably due to the action of zinc sulfate. This leads to the recommendation that all workers unloading and handling the zinc sulfate in the dry state continuously wear respirators whenever engaged on their job. One exception necessarily is made in that workman tending the hot water solution of zinc sulfate. Because of much wetness connected with his employment, the wearing of a respirator is impractical. It is here recognized that the respirators are worn at the present time most of the time; only on a few occasions have unloaders been observed neglecting themselves by discarding their respirators.

2) The boiling water tubs for zinc sulfate solution give rise to much steam. When we first arrived, the antiquated hood over these tubes was apparently not vented at all. During our stay, a new stack has been supplied which still is inadequate. Apparently more steam enters the room than is discharged through the stack. It is urged that this situation be bettered until substantially all steam be eliminated for the benefit of workers in this section.

3) One of the most objectionable of the lesser hazards connected with this plant is to be found in the cadmium recovery section. Here, after a series of chemical manipulations, the cadmium sludge, mixed with caustic, is smeltered and recovered as metallic cadmium to an extent



Lithopone Bagging. Lithopone is Essentially
Non-Toxic but Grossly Excessive Dust Exposures
are Undesirable. The Operation Here Portrayed
Calls for Improvement

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represented by the fact that each batch comprises about 500# of metallic cadmium. Cadmium is a highly toxic material and is perhaps not less toxic than lead. In the operation in question the fire box for adding heat to the smelter discharges its smoke through a makeshift pipe directly into the workroom. The smelter pot is not vented in any way. The accompanying ^{see Vol. II} photograph portrays this undesirable state of affairs. This very operation has led to a number of poisons, including one death, in another plant.

In this connection, a quotation is made from the League of Nations Encyclopedia on Occupation and Health, as follows: "In 1924, in a factory of chemical products, several workers engaged in handling the residue from lithopone manufacture and preparing cadmium were poisoned by the fumes. The inquiry revealed that the fumes in question were cadmium fumes rather than arseniuretted hydrogen." Of ten poisoned, one died.

The very definite recommendation is here proffered that this cadmium recovery work be carried out only under definitely better conditions and freed from the high presence of cadmium shown from the analyses of the samples of air collected during cadmium smelting. Another section of this report, "Cadmium Exposure" lists the results of the air analyses mentioned above.

4) The entire section in which zinc sulfate is prepared for lithopone manufacture is a low order of operation involving uncertain exposures to arsenic, arseniuretted hydrogen, manganese, lead, zinc sulfate, etc. The two definite exposures have above been described. A guarded expression is now made to the effect that this entire section would be helped by extensive modification. The humidity is excessive, water condensation drips from all ceilings and walls, wetness is everywhere present, etc.

5) It is understood that some changes are planned in the Black Ash Department. Remarks made in this item should be modified in relation to these contemplated revisions. Leaving the zinc component and taking up the barytes constituent, it may be pointed out that the barytes is far from pure, that lead may be present as an impurity. Occasionally arsenic is likewise present and some silica. As a result of kiln firing, the sulfate is changed over to the sulfide and oxide.

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Later this black ash is treated with water and possibly at times sodium sulfate, giving rise to barium sulfate, which after further purification is ready for lithopone manufacture. In the preliminary steps connected with barium, much dust is evolved, particularly at the lower end of the kiln where the sulfide and oxide are present. This dust is definitely caustic and acts as a skin irritant and depilatory. It is now recommended that unless the changes now contemplated take care of this dust situation, a dust entraining system be installed at the lower end of the kiln. It is conceived that much might be gained by conveying the untreated black ash to the leaching vats automatically with a screw conveyor or otherwise. The present arrangement of hoisting it in an elevator, filling by hand into skips, moving the skips a few feet, hoisting by hand crane and dumping by hand is conducive to much dust formation and apparently is uneconomic. If, however, it is necessary to weigh the black ash before its placement in leaching vats, then this suggestion may be less valuable. If some such arrangement as this is produced, the necessity for dust counters diminishes to some extent. Arbitrarily the standard is suggested that not more dust be tolerated in this room than 50 million particles per cubic foot of air when counted by the dark field procedure.

6) At the upper end of the kiln, in connection with grinding and hoisting, excessive amounts of dust are produced. The dusts here created are probably less dangerous than those at the lower end, but of this some uncertainty exists. At the present time much dust is induced by the vibration caused by the crushing. Apparently large quantities of dusts have settled about rafters so that whenever any vibration takes place, visible clouds of dust are produced. Also, it is observed that the hoist equipment is defective and fair quantities of the mix are dumped about the heads of workers. This is controlled to some extent by a makeshift platform which catches some of this spillage. It is now recommended that this entire building be freed of rafter dust in an effort to control the total amount of dust created in this department. Further, it is guardedly recommended that consideration be given to the necessity of a dust collecting system about the front end of the kiln.

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In order that proper interest may be stimulated in this enterprise, it is observed that baryta occasionally leads to dusty lung disease very similar to silicosis. These cases are uncommon; one was reported in 1926, in which definite lung changes were brought about. Of greater importance is the possibility that the irritation from barium compounds, particularly the sulfide, may give rise to cancer of the lungs. Of remote importance is the possibility that barium may possess sufficient radioactive properties to induce some injury.

It has been learned that plans are underway for the rearrangement of operations about the upper end of the black ash kiln. It is therefore inappropriate to make specific recommendations for changes further than to point out that present conditions are distinctly undesirable. Whatever new arrangements are installed should include adequate facility for the entrainment of substantially all dusts and gases arising in this general area and including the platform above the kiln where at the present time hydrogen sulfide gas is present in appreciable quantities.

7) At the present time, the handling of the black ash sludge after the separation of the barium sulfate, is carried out under objectionable conditions. In passing, however, it is noted that to some extent the workers handling this sludge are also the workers exposed to dusts from the untreated black ash. These workers definitely complain of the objectionable qualities of their work from heat, from dusts, from skin irritation, from lumps of settled ash falling from the ceiling and from steam and from wetness. One workman at this time complains of a caustic burn of one foot due to a leaky boot. It is granted that this is a difficult operation to surround with worker protection. No less, it is maintained that it is practical to minimize the dust, to evacuate the excessive heat, to remove the settleings and encrustations from ceilings, beams, walls, etc. throughout this department.

8) One of the disturbing features connected with the black ash work is the creation of hydrogen sulfide. This gas should command the respect of all persons. In any quantity they can be measured, it is dangerous. As noted elsewhere, measurable quantities have been established around this department. It is believed that one of the beneficent purposes served by

dust collectors will be that of removal of hydrogen sulfide gas as well. At this time no specific recommendations are made with reference to hydrogen sulfide control other than that at no time should the overhead openings in the building be closed. However, some hydrogen sulfide gas is generated in connection with the purification of the black ash. This portion of the problem will not be appreciably aided by the installation of dust collectors. For this reason, it is recommended that such steps be taken in the black ash washing room as will assure the absence of hydrogen sulfide in measurable quantities under all circumstances.

9) One of the chief complaints on the part of the black ash workers is from excess heat. Again it is noted that if dust collectors are installed these will probable move so much air as to dissipate some of the excess heat now present. On this account, no specific recommendations are made with regard to heat mitigation.

Now, after discussing the health exposures connected with the preliminary preparation, comment is made upon lithopone manufacture itself and its further treatment:

10) In the course of routine examinations for lead in the atmosphere, as reported in another section, much lead was apparently found in the dust to which lithopone workers are exposed. This very disturbing observation at once has led to the question that some lead is present as a definite constituent of lithopone, which is unlikely or that considerable amounts of lead is being blown into the lithopone room from nearby lead manufacturing operations. Third, there is a suspicion that some agent in the lithopone interferes with the accuracy of the test procedure carried out. At the time of the writing of this section, full laboratory return are not in, but the suspicion is great that for one reason or another, sufficient lead is present in the atmosphere in the lithopone room to produce lead poisoning, even though only traces be present in the lithopone itself. Final technical observations will be appended to this section and it is hoped that a full understanding of the situation will then be available.

11) Even though lithopone be non-toxic, and even though it be

free from lead, there is a limit to the dustiness to which workers should be subjected, even though the material leading to the dustiness be entirely innocuous. It is believed that much more lithopone dust is present in a few operations than should be tolerated. It is recommended for the bagging section either that this be changed over to automatic type of bagging of the dust free type, provided lithopone may be bagged automatically, and if this is not practical, it is recommended that a dust collector be installed about the bagging operation and nearby operations so that within that area workers will not be continuously subjected to an extraordinarily high intake of lithopone. Similarly, it is recommended that a dust collector be installed over the hopper on the floor above the bagging operations.

12) Great quantities of dust are produced about the lithopone building by the careless handling of materials, emptying of trays, and particularly by dry sweeping. Visible clouds of dust are nearly always present in various portions of this building. It is recommended that workers be cautioned to handle lithopone with an eye for no unnecessary spillage and further it is recommended that due consideration be given to the installation of vacuum cleaning system to supplant dry sweeping which now takes place. It is assumed that there is no practical method of doing wet sweeping and also that hosing down of floor and walls may not take place. If this assumption be in error, hosing down of many large portions of the lithopone plant as a substitute for sweeping would be highly commendable.

13) For the time being, many more workers in the lithopone department who are exposed to lithopone dust should be wearing respirators than is now true. One man is known consistently to wear respirator, but others are dilatory in this respect. Later on, when some of the innovations here recommended may have been installed, the wearing of respirators may be abandoned. At present, this would be unwise.

Final appraisal of the lithopone situation is to the effect that lithopone itself is non-toxic and its handling gives rise to no major problem. No less, certain refinements are in order in its manufacture.

Supplemental Notes

When all technical data were in hand, it was definitely established that the lead found in the Lithopone building was primarily due to air-borne lead from nearby stacks and apparently chiefly from the litharge and red lead stacks. The quantity varies from hour to hour and, of course, is much more prevalent in the direction toward which the wind is blowing. Lead has been found in the atmosphere outside of buildings in this area, originating from this same source. At the time that the red lead and litharge furnaces are being charged and when dampers are shaken, the quantity of lead thrown into the air is enormous. Freshly made lithopone itself has proved to contain no or only minute traces of lead, but rafter dust in these lithopone buildings does contain lead. Elsewhere, in various places, recommendations have been made that this general contamination of the air with lead be curtailed in order that non-lead workers and residents about the plant be not exposed to lead. It is the intent of this supplemental comment fully to exculpate lithopone as having an inherent content of lead.

Referring now to the handling of zinc sulfate from box cars in a loose, dry state, it is recommended that the steps suggested by the superintendent in charge be carried out to an even greater extent if practical. This is that the content of the cars as received be sprayed with water to a sufficient extent, through a sufficient number of times so that zinc sulfate dust will not be created in the process of wheeling this material from the cars to the solution tanks or storage bins.

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COMMENT AND RECOMMENDATIONS FOR OLD DUTCH PROCESS LEAD MANUFACTURE

This large operation provides enormous potential exposures to lead dust and is at the same time one of the most troublesome operations connected with lead use in this plant. From the point of view of the hygienist, the devout desire is that the whole Dutch Process might be abandoned in favor of some of the newer processes because these newer processes lend themselves more readily to protective devices. It is understood that white lead made by other processes than the old Dutch Process is, after all, lead carbonate, and not different to that made by the Dutch Process. If this be true, and if the Quick Processes are financially economic, then the industrial hygienist would like to lend their earnest support to the abandonment of the Dutch Process because of the difficulties attending worker protection.

In this department, practically one-half of the workers are showing signs of lead absorption. The percentage here is as high or higher than any other portion of this establishment. This is accounted for by the high quantities of lead found in the atmosphere, as shown in that other section entitled "lead analysis". Although these men wear their respirators with greater faithfulness than is true for almost any other factory investigated by us, it is impossible that any respirator will provide 100% protection or sufficient protection to make mild lead poisoning improbable. It is also noted here that respirators are not worn consistently by all workers. It is likewise true that some workers above the laboring class who are in and out of the dusty areas numerous times during the day do not wear respirators at all or at best very little.

Because of the distinctly bad situation connected with the stack work and particularly the drawing, which is very dusty, it is recommended that due consideration be given to the provision of facilities for positive pressure respirators of the non-helmet type for highly exposed workmen during periods of high exposure, chiefly drawing.

This plan would call for the installation of air lines at low pressure (below 6") down into each stack. These pipes should be set up with

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outlet valves at various levels and possibly with removable swinging arms and multiple nozzles, over one of which each workman might slip his hose line for his supply of fresh air. It is probable that the plant's air pressure line will not provide a suitable source of air supply. Obviously the intake of air must be sufficiently remote as to provide lead free air. It will not be necessary to wear helmets as a small face, covering the nose and mouth is sufficient. It is not anticipated that workmen will find this equipment much heavier than the present respirator. Since this drawing work is strictly confined to small spaces and for several years at a time, it is felt that here is an admirable situation for the wearing of hose respirators. However, since unforeseen difficulties may arise, it may be preferable to install pipe lines only in the nature of a pilot arrangement, embracing perhaps not more than six stacks. A faithful and intelligent tryout of the system over a period of six months will provide adequate information as to the merits of this innovation.

By actual tests, much lead has been found in the atmosphere about the molten lead pots associated with buckle casting. The chief source of dust here is from the skimmings removed at frequent intervals during the work period. Surrounding the entire lead pot area, much accumulated settled dust is present. The skimmings are merely dumped on the floor, requiring additional handling in connection with removal. The exhaust system now installed over this pot moves very little air and fails to pick up dust artificially stirred up near the doorway. No thermostat is utilized in connection with this operation. Consequently, workers know only by rule of thumb the temperature that exists which temperature probably varies appreciably during the day. Since high temperatures produce more lead fume and more dross because of increased oxidation, it is recommended that thermostatic control be provided for this lead pot and that the temperature be kept as low as is consistent with the needs of the operation. Since it has been stated that the operators change the temperature from time to time during the day, in order to meet peculiar requirements, it may be desirable to install only that type of thermostat which will provide that maximum temperature actually required for operation purposes.

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In the handling of used tan bark, there are certain stages and operations wherein this bark may be wetted down. This is desirable wherever practical, because much lead is mixed in with this tan bark and dusty atmospheres are readily produced. It should be the continuous endeavor of the management to obtain from workmen full cooperation in wetting down every dusty operation where it is possible so to do.

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Lead Recovery from Refuse of Dutch Process
of White Lead Manufacture. A Dusty Operation
Partly Due to Defective Mechanism Which Should
Be Remedied

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COMMENT AND RECOMMENDATIONS CONNECTED WITH LEAD RECOVERY FROM TAN BARK

This small unit gives rise to a fair amount of lead in the atmosphere as shown by various tests made. The chief offender is the lead stirred up from the handling of the dried out tan bark as it is thrown into the elevator boot. Also, enormous quantities of lead are temporarily produced in connection with the shoveling out of the completely burned bark ash. Since the supply of this material to be recovered lies outside the building, it is inevitably wet some of the time. Consequently, the question arises as to why this may not be wetted down at all times when freezing would not take place. Thus at once would be eliminated all prospects of dustiness.

In connection with furnace loading, on our first arrival, this work was much more dusty than at present, due to the fact that many flues were clogged up to the point that all stack action was practically absent. Lately this has been remedied and this source of increased dustiness no longer exists.

The operator complains that the fan installed for venting this room operates improperly and runs in reverse fashion. Even though this be true, it is unimportant as no good purpose is served by this overhead fan. The need exists for an exhaust system near the lower door of the furnace, and preferably on either side of the furnace. These two lateral intakes in truth will not pick up all the dust but will go far toward entraining the dust created, in connection with shoveling out of ash. It is possible that the fan now installed, but which serves no helpful purpose, may be introduced into a new system as just mentioned.

The ash removed from the furnace and laid out in windrows on the floor should be sprayed with water (not hosed) during the process of emptying out the furnace, immediately on removal from the furnace, shovel full by shovel full—that is, one worker should shovel, the other should spray. Lead from this recovery stack is one of the contributing offenders to the general atmosphere contamination so often discussed in this report. It is possible that this lead should be recovered.

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COMMENT AND RECOMMENDATIONS FOR THE LITHARGE AND RED LEAD DEPARTMENTS

If reference be made to those other sections dealing respectively with air analysis for lead content and with blood examinations for evidences of lead absorption, ready proof may be found that the manufacture of lead oxides is associated with definite exposures. Using the quantity of lead of 1.5 milligrams of lead per 10 cubic meters of air as a yardstick of safety, it may be observed that in this department there are some places presenting as much as 200 times the minimum quantity of lead regarded as dangerous. Of greater significance is the fact that approximately one-half the workers present suggestive signs of lead absorption.

On these accounts, it is felt that here is a department which must be made the recipient of extensive modifications. A number of suggestions and recommendations now follow:

1) In another section of this report, a discussion is provided with reference to the washroom and locker room for workers in the general lead manufacturing area. The need for much more extensive accommodations was emphasized. It is urged that this matter be given consideration and that at a very early time better accommodations be provided for these many workmen. Congestion is enormous and exposure to lead is provided directly in the wash and locker rooms.

2) From the stacks leading from the furnaces in this department, much lead is poured into the open atmosphere, to the point that workers in nearby departments probably are indirectly exposed to lead. In writing up the lithopone section, it was noted that apparently much lead was present in the lithopone dust. It is now felt that this lead represents a contamination of the lithopone with high quantities of lead escaping from the stacks associated with red lead manufacture. Of even greater significance is the possibility that this discharged lead is being carried several hundred feet and might affect residents and shop keepers along 115th Street and conceivably workmen in the Kensington Steel Plant. This constitutes a prime legal threat, which matter is being discussed with Mr. MacDowell, the Corporation's chief counsel. When as much as 100 milligrams of lead are present in the atmosphere of the lithopone building, in each 10 cubic meters of air, and assuming that no technical error has been permitted to arise in the method of analysis,

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of which
the possibility ^{is} being investigated at this writing and accepting
the condition that no lead beyond a trace can be present in the lithopone,
it becomes enormously important to give consideration to the large quantity
of lead being poured out of the various stacks in the lead manufacturing
departments. While certain quantitative measurements have been made,
indicative of contamination of the general atmosphere, the best evidence
may be found in seeing actual clouds of red lead emerging from the furnace
stacks. It seems probable that commercial losses are considerable, which
might justify remedial measures, primarily contemplated for worker and
citizen protection. At any rate, it is recommended that such steps be
taken as will eliminate the apparent wide contamination of the general
atmosphere by lead, discharged primarily through stacks from red lead
and litharge ^{and} bark burning furnaces.

3) In this department, there are now in operation six different
dust collecting or dust arresting systems. Insofar as protecting workers
is concerned, it appears that no one of these systems is worth a great
deal. The design is extraordinarily bad—certain systems are over-loaded,
none are entirely suitable to the requirements of worker protection and
of greater importance, some of the worst offenders as dust producers are
not equipped with any dust collectors, good or bad.

During the period of our investigation, an engineer connected
with a manufacturing company has investigated this same problem, but quite
apart from our investigation, and unknown to these investigators. This
engineer was not seen by any person connected with our own group. Recogn-
izing that this engineer has equipment to sell and pointing out that we
have no interest whatever in his company or his wares, it has no less been
deemed desirable to include an engineer's appraisal of this same situation.
This appraisal now follows, but the recommendations made are not necessarily
subscribed to by us.

RED LEAD FURNACES

Four Gas-fired Furnaces to Common Stack, Using Three Smoke Outlets from
Each Furnace.

Two of these at the top are now practically closed. The rear
smoke outlet with damper is controlled according to heat. It is through this
opening at the rear that gas or fumes from lead and litharge escape. Much
of it deposits in the breeching at the back of the furnaces, and evidently

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considerable rises from the main stack to the atmosphere. The amount of material passing out in the furnaces through the stack to the atmosphere, or deposited in the breeching in a unit of time is not easily determined. The loss of fumes in the Red Lead and Litharge, resulting from loading and unloading the furnace pans through the front door was very roughly determined as follows: A plate measuring 8" x 10 1/2" was covered with material during the time the front doors were open to the amount of 10.95 grams in a period of time of approximately one minute. This was red lead. Some material escapes continually through the front because of the leakages at both the lower and upper doors, but the amount of loss while actually loading and unloading is much greater over a period of only fifteen to twenty minutes.

It is recommended, first, that a hood, 50" wide x 18" deep, suitably tapered upwardly, and connected to the dust pipe for each furnace, be connected to the dust collector on the level of the fourth floor above the mill room.

Coal fire furnaces located on the other side of the mill room are producing practically the same amount of loss at the front doors when loading and unloading. The flue arrangement, however, differs considerably because of coal firing. The collector for this, arranged the same as the four first mentioned gas-fired furnaces should be the same, and would join the same collector on the level of the fourth floor. These furnace fumes will enter a classifier or coal chamber pre entrance to the bag or tubular type of collector.

Due to the comparatively low temperature at which the furnaces are operated, being an average of about 1020°F., it would be possible to cool this down to the point where all of this could be drawn into a tubular collector at a very high rate of velocity, the collector also equipped with a classifier and cooler so that no losses from furnaces could occur. This, however, would entail considerable expense, as these collectors would necessarily be of considerable size, and would suggest at this time that this be deferred until the recovery of the losses at the front of the furnaces had really been proved profitable.

Corrections

The present dust collecting equipment on the fourth floor of the mill room appears to be entirely overloaded. Thus, the velocity of the air throughout the blow-pipe system is too low to convey the dust effectively. Many of the horizontal pipes, including some of the smoke pipes, easily fill with material, and thus further reduce the effectiveness of the suction at the various outlets.

Most pipe construction is incorrectly joined up where one pipe enters another. In no case should a pipe enter another pipe, even of larger diameter, at right angles to same. All branch pipes should lead into main trunk lines at an angle of less than 30 degrees, and preferably of 10 degrees where possible; otherwise, there is a choking up in the trunk line.

Invariably, the connections to elevators are improperly placed, thus causing dust to congest the air rather than remove the pressure. All take-offs for elevators should be at the top, or head, far enough away from the discharge of the pockets so that it will not disturb material being carried.

The method of shaking or cleaning the bags from the several bag collectors is ineffective. This is usually accomplished by rubbing the bags from top to bottom with a long pole, while the fans are in operation. The result is that the cloth impregnates to the extent that it builds up a back pressure in the system. Also, much of the material goes on through the fabric, and it is deposited on the floor. Overhead, immediately above the bag collectors, are roof ventilators. These also exhaust considerable material out to the open atmosphere every time an attempt is made to clean the bags. The capacity of the equipment concerning the bags themselves is still too

small, even if the method of cleaning them were more effective. However, effective cleaning would very materially increase the present capacity. It is observed that in some cases more than one blower is used in discharging dust to the bag collectors. The usual result is that the system becomes unbalanced, or one blower working against the other. In good practice, not more than one blower is served by a single collector. One large blower, with ample capacity to serve a number of pieces of equipment, such as mills, sifters, elevators, floor sweeps, etc., could be used to serve one large collector with the use of gates in the various lines to the equipment units, and thus balance the entire system and control it. This would be idea, and far more efficient than many blower units that are now used.

It is assumed that the Company does not wish to make a radical change in present buildings, and that any new equipment going in is merely to meet the present situation to reduce the health hazard and recover losses so far as possible, and that later, when more radical changes are contemplated, any new dust collecting equipment that may now go in can again be used by simply adding sections or units. The dust tube collector is designed along these lines. It is sectional in construction, and can be added to very easily at any time. Not only can the capacity be increased to an unlimited extent, but the shaking of equipment for effectively cleaning fabric can also be extended. The means for unloading hoppers can be so designed that they can be extended and material fed to any desired place.

New Dust Collectors in Mill Room

It is observed that there are a number of floor feed openings for the feeding of elevators with material drawn from the furnaces. These should be connected to an independent new dust collector with high velocity so that all spillage now occurring in the floor may be eliminated. The floor feeds should be designed with grates, and over this is where the material should be handled. With suitable suction connections under the grates, there would be no spillage.

Possible Space for the New Collector

On the fourth floor of the mill room, north end, is a large bag collector, having 39 12" bags, not operating, and one set of Raymond type bag collector, measuring 84" across, not operating, covering a space of 20' wide x 16' long and 12'4" clear from floor to ceiling. This space could be properly used for the installation of a new collector of modern type to serve the two sets of furnaces, new mill room dust connections, and considerable additional equipment now not adequately served.



Litharge Milling. Highly Dusty Operation.
In the Absence of Consistent Wearing of
Respirators, Distinct Exposures May Arise

In particular, the exhaust hoods connected with barrel filling with litharge and red lead are very bad. These are located approximately 4 feet above the lower level of filling and are offset about two feet. Whatever dust is entrained is drawn by the workers breathing zone, as it passes from the point of origin or where the drum is being filled to the intake of the exhaust. In this instance, the intakes for dust exhaust should be located very close to the open end of the drum and should not be further away than 6".

It is the intent of this inculcating discussion to emphasize that substantially no features of the present dust collecting system are acceptable from a hygienic point of view. It will be necessary extensively to redesign the installation and to make increased provision because present facilities are over-taxed without accomplishing a great deal of good. Exhaust from these dust collector systems contribute to the totality of general atmospheric contamination, discussed in the preceding item.

4) Whatever may be done with respect to dust collecting systems, it is recommended that hoods be installed over the top doors of all furnaces in operation. No attempt is made to specify the size, design or quantity of air moved by these hoods, nor is it the duty of these investigators to state which, if any, of the present system should be connected up with these new hoods. No less, the recommendation is made for a prompt installation of protective devices of this character.

5) During recent months, according to stories told these investigators, two or three inspectors from some governmental agency looked over the operations in this department and recommended that no clean-up work be done, that dust be allowed to accumulate and settle and should not be stirred up. It is to be hoped that these inspectors were misunderstood. If not, their recommendations have certain elements of foolishness in them. No less, the workers in this department have been considerably influenced by this governmental injunction and have not been as active in ordinary housekeeping as is desirable. Of course it is inexpedient to do extensive clean-up work when large numbers of workmen are on the job and particularly when some are not wearing respirators. If this be the bone of contention, then such time should be found as when the smallest number of workers are likely to be exposed. These investigators are advised that there are certain areas where wet sweeping is quite permissible and even hosing down may take place in a smaller number of places. All this is highly recommended. Even the use of wet sawdust is better than dry sweeping. In fact, dry sweeping on a general basis is looked upon with disfavor. At this time, when so much dust is produced, very little will be gained by a wholesale clean-up of rafters and all projecting ledges, and such is not recommended, but at a later time, when the dust collecting facilities, such as are recommended are installed, an elaborate housecleaning is in order for this department.

6) In that section dealing with protection in the lead stacks, recommendations have been made that certain workers who move very little in their operations be provided positive pressure hose masks. These would be recommended for workers in the Litharge and Red Lead Departments except for the fact that most workers move around far too much to permit this change. However, it is now said that if there be any workers who consistently are kept at fixed points and do not move about over a radius greater than 15 feet, in connection with filling operations, furnace operations, etc., consideration be given to the advantages of positive pressure respirators over filter respirators. Unfortunately, the prospects do not seem to be good for their use in this department.

7) In order that there may be no uncertainty about the needs

for this department, the general recommendation is made that all necessary steps be taken such as will lead to the reduction of lead in the general atmosphere to that quantity so that a workman will not receive into his body more than two milligrams daily. At the present time, he is more likely to inhale 200 milligrams in the absence of respirator wearing. The respirators now worn are good—in fact excellent—but no respirator is apt to be more than 95% efficient and in this department the 5% of inefficiency provides ample opportunity for practical lead exposures.

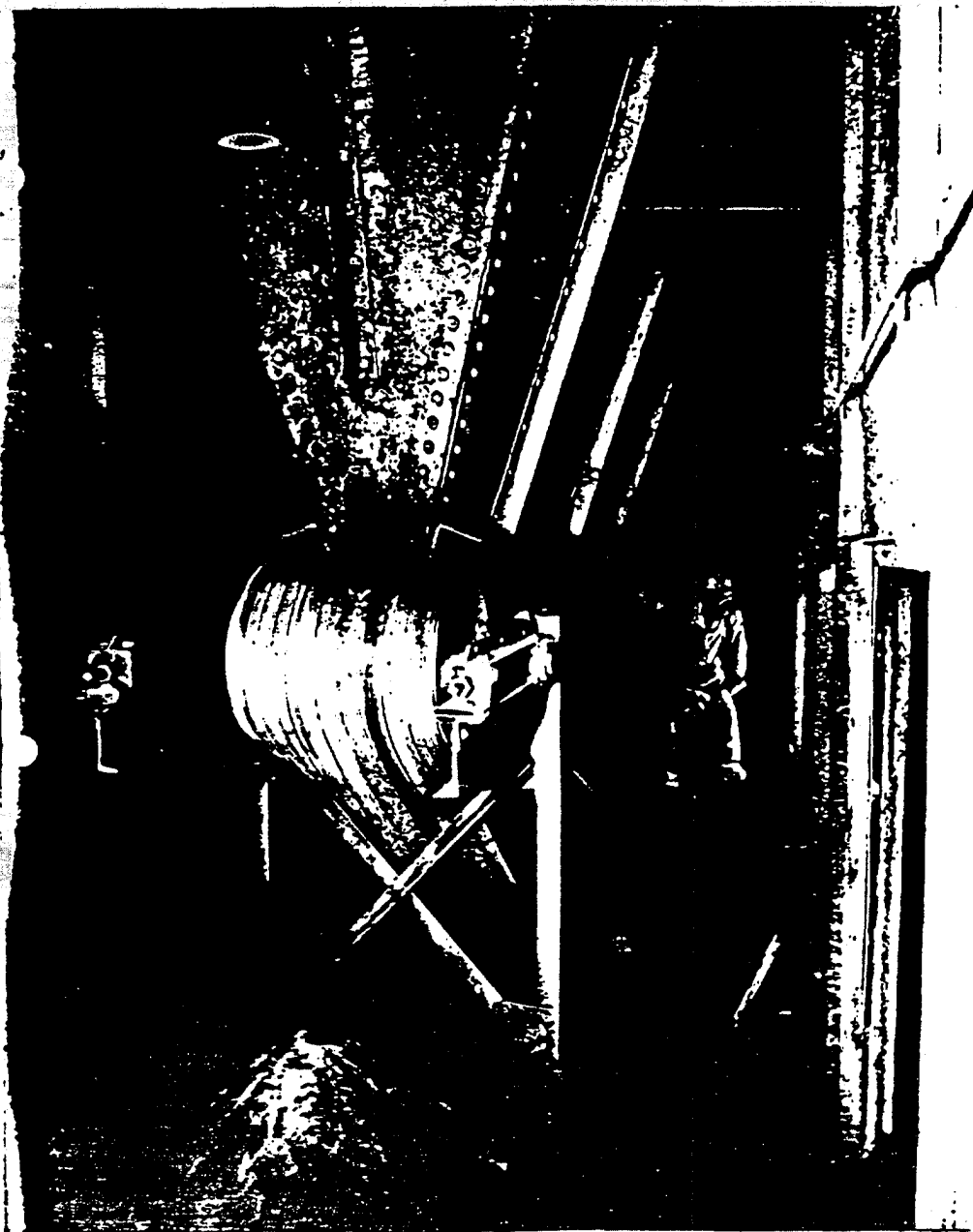
COMMENT AND RECOMMENDATION FOR QUICK PROCESS OF WHITE LEAD MANUFACTURE

In connection with discussion for exposures contaminating the Dutch Process of white lead manufacture, it was pointed out that it was most difficult to eliminate atmospheric contamination with lead. Also in that section a distinct preference was expressed for other methods of white lead manufacture as appraised in terms of possible exposures for workmen. Now in discussing the Carter Process, or, as it is here termed, the "Quick Process," it is again to be noted that complete protection is not easily obtained. Primarily these difficulties grow out of physical behavior of white lead as manufactured by the Quick Process which is not easily entrained, does not move through conduits with facility and altogether behaves in an onerous fashion. Moreover, the situation is made troublesome through the fact that acetic acid leads to the destruction of many types of materials commonly used in the protective apparatus. Fully recognizing the difficulties of the situation, a number of suggestions are now made.

A. Both from air analyses and from blood examinations of workers it is established that considerable quantities of lead pervade the atmosphere in this department. Other sections of this report respectively present these findings. The general atmosphere of each cylinder room of the Quick Process department contains very high quantities of lead. All of the subsequent recommendations made are directed toward the elimination of high concentration of lead wherever found.

B. The initial step connected with this process is the melting of lead preparatory to atomizing into steam in a large chamber near by. Although this melting pot is equipped with extensive devices for evacuating lead fume and dust, the pot is so neglected that much lead dust has settled about the pot and much is stirred up at the time of dropping pig lead into the pot. The atmosphere in this area is well laden with lead. Also the operator about this furnace is showing signs of lead absorption. It is recommended that this small area be

See section on lead pot temperatures.
See section on air analyses for lead.
See section on blood tests for lead.



Bottom of Chamber in Which Atomized Lead is Prepared for Quick Process White Lead Manufacture. Although Extensively Automatic, Work Connected with This Operation May Provide Exposures to Lead Dusts

given a general house cleaning, that all settled lead be collected and disposed of, that dross be cleaned out of the pot area at fair intervals such as two or three times weekly,--all to the end that subsequent analyses of the atmosphere may reveal no dangerous concentration of lead at any time.

C. It is noted in many places that large quantities of lead are being discharged into the general atmosphere at this plant, and this lead is sufficient to produce signs of lead absorption in workers as far away as two blocks. The operation under discussion is perhaps not the worst offender but no less is a contributor to the situation. Later a general recommendation will be made that ways and means be found to bring this general problem under control. Therefore, no specific item is made of this one source of contamination.

D. At the bottom of the blue lead manufacturing chamber there emerges at the north end a belt conveyor. Due to leaks, considerable lead is thrown into the atmosphere at this point. Also, the operation itself, apart from leaks, contributes some lead through that machine. It is recommended that these leaks be repaired immediately. Thereafter if too much lead is still present as determined by atmosphere analyses, it is recommended that this small area be completely housed in in order to completely control this lead exposure.

E. In the blue lead cylinders too much lead dust is produced at the time of the initial filling of these cylinders. As the first step in eliminating this exposure it is recommended that some device be created whereby this lead is discharged into the cylinder with complete closure existing between the opening in the cylinder and the discharging point of the worm conveyor. Just how this may be accomplished readily may be worked out by the engineering staff.

F. At the present time the end of every cylinder opposite the gassing end is theoretically hooked up with a sanitary conduit of wooden construction which rises to the top of the building and there discharges. It is obvious to all that these appliances are worn out, rotted, and never

were of any great value. The chief difficulty connected with their operation is that considerable moist acid vapors are produced during part of the operation while at other times dust is created. The moist acid wets the walls of any conduit leading to the deposition of the dust on these walls rather than passing to the outside as is desirable. Moreover it seems impractical to attempt to collect this lead either by bag system or cloth filter. This is in part because of the action of the acetic acid and in part because of the wetness of the dust. To meet this situation it is desirable that the opinions of the engineering staff be sought. We, however, recommend that consideration be given to the prompt tearing out of the now useless, rotted sanitary conduits and that these be replaced with some more durable material such as terra cotta, paraffin treated wood, transite, etc. This new system should embrace induced air motion and in addition should depend on wet washing of the air in the disposal of the collected lead material. It is recognized that these statements are somewhat vague, but they are made so through desire. Skilled engineering guidance will be a requisite to the creation of the proposed system for the collection of lead in this department.

G. At the time of the emptying of the cylinders both from the blue side and the white side, a fair amount of dust may arise, but this is not inevitable depending upon the state of moisture of the product. It is noted that one system of dust collection is already in operation and quite successfully, being connected with a housing about the worm conveyors. It is believed that this same system may be extended to all other conveyor units and that this source of dust may thereby be properly curtailed. No attempt has been made to measure the efficacy of the one system in use, but casual opinion is to the effect that this is one of the few successful ones about the plant.

H. Even though these appliances be installed in full measure it will probably be necessary for the workers to continue to wear respirators for an indefinite time. At a later date additional tests will be

made to determine the concentration of lead in the atmosphere. At that later time when the concentration approximates 1-1/2 milligrams in 10 cubic meters of air, approval will be given to the non-wearing of respirators.

I. Various other sections of this report discuss matters connected with this department or the work thereof. For example, a strong recommendation is made for increased wash room facilities for lead workers. This discussion appears partly in connection with the section on wash rooms and partly in connection with recommendations for other lead using departments.

COMMENT AND RECOMMENDATION FOR WHITE LEAD FINISHING

DEPARTMENT

At just what point the Dutch Process division ends and the White Lead Finishing division begins is a little uncertain. On this account it is recognized that in this discussion at least one series of operations probably belonging to the Dutch Process division is discussed in connection with the finishing work.

On the east side of the lead oxide furnace hall is located a small building of four floors where the Dutch white lead is separated from its remaining content of coarse metallic lead. This series of operations leads to the collection of large quantities of "lead nickels" which are used in the manufacture of litharge, and a rather coarse state of the corroded lead, some of which is used in the manufacture of red lead. The three upper floors of this building house machine operations that are almost entirely enclosed. These three floors are especially free from gross quantities of lead, and with one exception the entire sanitation acceptable. The one exception is trivial. A number of oil leaks are present in the pipe lines. Instead of repairing these leaks, piles of tan bark are provided on which oil may drip. This is not important, but, if at all feasible, these leaks should be eliminated in order in turn to eliminate the necessity of the tan bark accumulation.

The first floor of this building stands in marked contrast to the cleanliness of the floors above. Here as much as one-half inch of lead is present on the floor. The barreling operation produces much spillage and dust. Further, this room is unnecessarily littered by the presence of waste material.

It is recommended that this room be extensively cleaned up, that the present dust collecting system be extended to the hopper above, that the barrel filling operation be extended to the filling operation itself, that the "lead nickels" be not piled up on the floor but handled



White Lead Filter Presses. Extent of Hazard is in
Proportion to Quantity of Dust Permitted to Arise

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that chemists exposed here should wear respirators, but this should not be a permanent arrangement because the improved laboratory regime should make this unnecessary.

On the third floor the outstanding exposure to lead is situated at the take-off end of the drying oven. Here numerous trays of white lead are dumped into a hopper leading to the grinding mill below. Two intakes for dust are located about this chute, but much lead no less escapes into the atmosphere. It is recommended that the exhaust system at this point be so redesigned that better protection is provided. On this entire floor, white lead is literally coated on all surfaces, particularly floors. The question is raised as to the possibilities of flushing down walls and floors in certain portions of this area.

On the second floor a fair amount of dry mixing takes place, such as in connection with the Silo mixing. Much white lead is produced in connection with such operations and contaminates the atmosphere of this entire floor. This is reflected in the fact that in the department's offices located on this floor, enough lead is present to produce lead poisoning; in fact, certain persons located in these offices show signs of lead absorption. However, it is observed that those persons spend some time in the manufacturing areas in the plant so that their lead absorption may not be due to the lead present in the air of the offices.

Perhaps the greatest offender of all in the production of lead dust in this department is found on the first floor in connection with lead barreling. Although this operation is walled off and is exhausted, much too much lead dust is permitted to arise. During the barreling operation the make-shift door to this room is not closed so that much lead passes out and endangers the workers manipulating pulp lead which in itself provides much less of an exposure. It is believed that at least two things may be necessary in further controlling this outstanding exposure. First, the exhaust system is inadequate. Greater quantities of dust should be picked up at the point of barreling. Also the exhaust system should be extended so that there is an intake of air off the

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in containers, and that unnecessary litter be cleared away. Lastly in this connection it is observed that the basement section which is used for storage should be protected from dust coming from the first floor above. The stairs leading from the first floor to the basement contain about one-fourth inch of white lead all over. The rectification of conditions on the first floor will automatically take care of the needless contamination of the basement department below.

No attempt is made to follow through the Quick Process lead or the Dutch Process lead in an orderly fashion through the finishing operations. The following disjointed comment no less is associated with the real danger points of this department.

The fourth floor is almost entirely devoted to the water washing and sedimentation of white leads. Nearly all portions of this entire area are whitened by lead but no great amount of white lead is present in the atmosphere. It of course would be preferable if these lead incrustations were not present, but it is not known how to achieve this in practical steps. Therefore, no recommendations are made save one; namely, a few of the anti-splash extensions of the tanks are worn out, thus paving the way for unnecessary spillage onto the floor. It is suggested that this simple matter be remedied. Wherever possible the area on this floor should be hosed out from time to time in order to prevent the building drying out of accumulated lead. As long as the lead is wet, the dustiness will not arise.

Also on this same floor is located the white lead laboratory. At least three persons in this laboratory present some evidences of lead absorption. Also, from lead analyses of the atmosphere, it is known that dangerous quantities of lead are present. Many hundreds of samples of lead are observable about this laboratory, and these are handled with apparent carelessness. It is recommended that the entire regime of this technical laboratory be altered to the point that undue quantities of lead may not be present in the atmosphere. Inevitably this will call for better house-keeping, may necessitate an exhaust system, may require that this laboratory be considerably enlarged. At the present time it seems desirable

general work space. Possibly this should be located near the door in order to prevent the passage of suspended dust through this opening. Further, it is believed desirable that the space provided for this isolated room be enlarged so that it may not be necessary to continue to move barrels of lead down this small room during the process of barreling. These matters, of course, represent engineering problems so that the hygienist contents himself with urging that the exposure be much diminished.

In other sections of this report, a discussion is presented as to the washroom and eating facilities for all of the lead manufacture division. Also a request has been made that the three women working in this department be provided a toilet since now it is necessary to leave the building, cross over the railroad tracks and the street, pass up to the second floor of a paint manufacturing building in order to gain access to toilet facilities.

Many workers in this department engaged in duties substantially free from direct exposures are no less endangered by lead originating in nearby operations.

Along the worm conveyor from the Quick Lead Process there are a number of leaks which contribute to the sum total of dust. It is probable that this complaint should have been made against the Quick Lead Process operation as the actual line of demarcation between the two departments is not entirely clear.

In general, the housekeeping throughout this department is open to some unfavorable criticism.

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COMMENT AND RECOMMENDATION FOR COAL TAR PRODUCTS MANUFACTURE

During the tour of investigation of this plant there has been put into operation a benzol distillation plant. This plant will properly produce from 1,000 to 1,500 gallons of benzol daily. At this time, it is too early to establish if this benzol operation will be associated with any exposures. It appears that the system is so entirely closed as to provide no opportunity for benzol evaporation. However, during the process of construction, the workers have complained of unusual headaches because of leaks. This dangerous stage is now passed, and no real apprehension is entertained that benzol poisoning will arise. No less, it is recommended that from time to time those workers employed in this operation be subjected to the urine sulphate test for benzol. This test is described in another section. Results from this test will indicate whether any of the operators are taking benzol into their bodies.

Large quantities of asbestos fiber are used in the manufacture of certain coal tar products. Considerable dustiness is produced by the asbestos. Up to recent weeks the operators manipulating asbestos have not worn respirators. For this reason, those longest exposed were subjected to x-ray examination of their chests. Two presented remotely suggestive evidences of asbestosis. While no great attention is paid to this finding and while these workers should not be concerned about their possibly trivial industrial lung disease, it must be recognized that this is a dangerous material, calling for precaution. Three protective steps are suggested at this time.

a.) Whenever manipulating asbestos, workers should consistently wear respirators.

b.) The leakage of dusty materials around hoppers which now contaminates to a slight extent the air of the floor below should be stopped by filling in crevices, etc.

c.) This irregular operation should be distributed among considerable numbers of workers so that no two or three workmen should

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regularly carry out this operation. If there be sufficient personnel, no one worker should be exposed to asbestos handling more than three months out of the year.

Cleaning of the drums with caustic out in the open air works a hardship on the men during the cold weather. It is known that during extremely cold weather this operation is abandoned, but during the warmer days of winter this operation is performed. Elsewhere in this report a discussion is provided with reference to the installation of a central drum cleaning section. It appears that another good reason for this recommendation is to be found in the undesirable type of drum cleaning work carried out in the Coal Tar plant. At any rate, it is pointed out that present practices are not commendable chiefly because of the punishment of workers during the colder months.

The removal of the Insecticide division to another state has freed this Coal Tar plant from some of its more dangerous operations. However, some disinfectants and disinfectants are still made, involving the extensive manipulation of hot phenolic chemicals in open systems. It is recommended that the one large open vat devoted to this purpose which is now equipped with an exhaust depending only on stack action be equipped with induced currents of air in order to eliminate the possibility of injury from phenolic vapors.

Practically all of the raw materials and products of this plant are well known as skin irritants, and a few might give rise to skin cancers. It is urged that a high type of personal hygiene be encouraged among these workers. Further it is suggested that all workers continuously be under scrutiny for skin diseases and that any skin disease be brought to the attention of the medical department shortly after its first appearance.

COMMENT AND RECOMMENDATION FOR PAINT AND VARNISH DEPARTMENT
(VARNISH SECTION TREATED SEPARATELY)

Prior discussion brings out the fact that this department occupies a series of buildings, embracing 13, 19, 20, 21, 23, 9, 10, 11, 12, etc. With the exception of enamel work in building 23, the majority of paint operations are conducted in buildings 18 and 21. It is quite understandable that this department should be located in some of the oldest buildings in the institution since undoubtedly paint manufacture long antedated such operations as lithopone, chemical products, lacquers, etc. This very quality of venerableness of the paint manufacture department introduces trying problems connected with sanitation and hygiene.

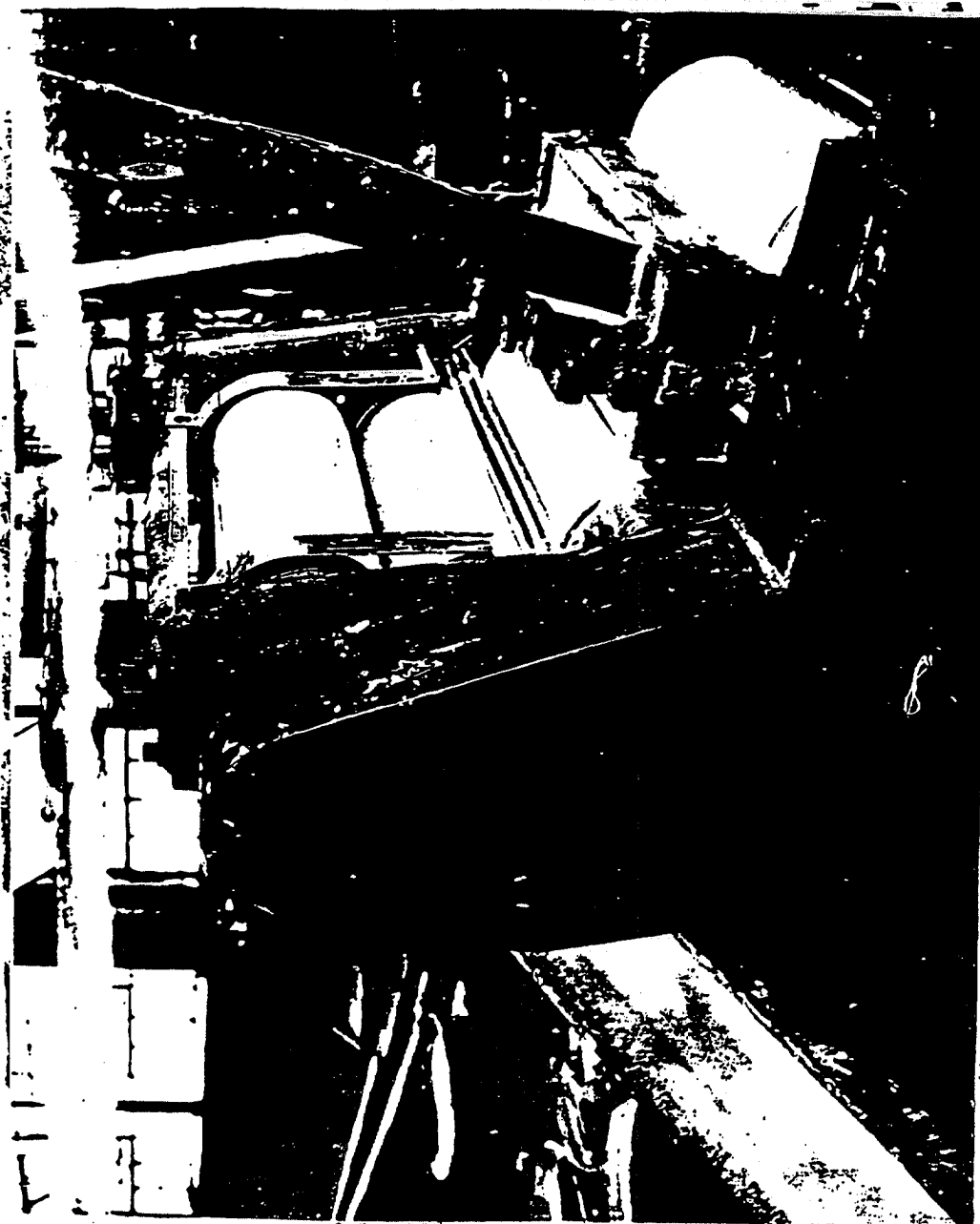
At once it may be said that operations in buildings 18 and 21 are carried out under physical circumstances that make almost impossible the procurement of sightliness, orderliness, and general acceptability.

With the exception of definite lead exposures in building 13 and limited exposures elsewhere, it is not maintained that in these buildings there are outstanding exposures or threats to the health of workers. On the other hand, the entire situation as to accumulated incrustations, settled dust, worn out flooring, noisy machinery, ineffective lighting, filthy toilets is such as to give a very bad impression.

The stand is here taken that there is little justification for the installation of expensive protective devices at any point in these two buildings. The temptation is to urge that these buildings be replaced or extensively remodeled. This at once would solve all or many of the hygienic difficulties. This recommendation as to tearing out these buildings is not made, but it is recognized that economic situations within a short time will make necessary that new types of machinery replace much of the obsolete equipment now extensively in use. Since one of the outstanding problems of this plant is that of work congestion rather than worker congestion, it is inevitable that in a short time some one or some of the larger departments must be removed into nearby space

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Roller Type of Paint Mill is Superior to Stone
Mill and Eliminates the Possible Dangers Connected
With Stone Dressing.

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in order to remove the work congestion in other departments, such as Dry Color, Chemical Products, etc. Thus, the prophecy is hazarded that Paint Manufacturing Department when rebuilt will be located apart from its present situation. Much would be gained from the point of view of plant sanitation when the Paint Department occupies different buildings and makes use of different machinery. While this is desirable, these investigators refuse to make any issue of this problem on sanitary or hygienic grounds because the belief is that actual danger to workers is low. On the other hand, when economic conditions justify this program of rebuilding, the industrial hygienist will lend full support to any such step.

A number of installations of a protective nature might be made in the Paint Manufacturing Department but are here omitted on the ground that every installation would be too expensive in proportion to the good that could be accomplished and in proportion to the value of the buildings in which these installations might be made. On the other hand, a few modifications are imperative. These are now mentioned. In building 21 at least two of the toilets are beyond the pale. These are condemned vigorously as being unworthy of this company. The one on the first floor at the east end is most deplorable and should be visited by anyone who is skeptical as to the justification of this strong language. The others are slightly better.

In building 13 on the first floor there is one large toilet and washroom area which ostensibly has been abandoned in favor of a good type of washroom on the floor above. This room is partly filled up with raw materials and materials in process. Notwithstanding, this toilet room has not been abandoned. Extensive use of it is made by workers on the first floor but in the absence of adequate cleaning service. It is recommended that this unsightly room be in fact abandoned or else reconditioned and put into service. It cannot remain in this present condition. Either close up or fix up.

In building 13 atmospheric analyses have revealed high concentrations of lead chiefly connected with dry mixing. It is recognized, of

course, that in this building lead is settled on every projecting object, incrustated on all floors, machinery, etc. There is no practical step whereby this lead may be removed in its entirety. This has been discussed in the introduction to this section. Now, however, it is emphasized that so much additional lead is produced at the time of mixing that workers should wear respirators at least on the mixing floor and possibly on the grinding level as well. It is not sufficient merely to wear respirators while actual dumping of lead into mixers is taking place. The dust produced hangs in the atmosphere indefinitely and involves not only the mixer himself but is carried to all portions of the second floor. With considerable reluctance the recommendation is made that more respirators be furnished and that respirators be worn to a greater extent. On this floor two workers are showing signs of lead absorption. Reference is made to that other section of this report dealing with lead analyses for evidence of the presence of lead in the air breathed by workers in this section.

Note: At the rear of the first floor of building 18, a small amount of work is devoted to utensil cleaning in naphtha. Because of considerable evaporation taking place here, it is recommended that this cleaning unit be fitted with a hood and exhausted to the outside of the building and upward but without induced air currents. The use of motor powering for this small unit appears not to be necessary and is therefore not warranted.

With reference to Department E located in a series of small buildings, 10, 11, 12, etc., a number of suggestions are made:

a.) The semi-enclosed tank in which paint and varnish remover is made should be equipped with an exhaust duct connected with the present exhaust system provided for paint and varnish remover filling. This innovation may be provided at a cost probably not exceeding \$5.00 because of the proximity of the exhaust conduit.

b.) In this department is manufactured a brass polish termed "Brass Brite," consisting of oleic acid, finely powdered silica, and

aqueous ammonia, 26 percent. At the present time only about 200 gallons of this product are made weekly. Of the 26 percent ammonia, only about five gallons enters the individual batch. Because of some discomfort to the workers, it is recommended that whoever handles the ammonia and whoever does the filling of containers with this product be furnished with ammonia respirators and with goggles. Goggles are more needed by the handlers of the concentrated ammonia than for the container fillers. No less it may be well for both to wear these protective appliances. Ammonia respirators may be bought from most any manufacturer, but in this case because the hazard is minimum, the lightest, smallest variety should be procured.

c.) In connection with paint and varnish remover filling, a good hood is present over the filling point which is connected with the power exhaust system. The evidence in hand indicates that the present protection is adequate. Notwithstanding, because of the highly dangerous nature of wood alcohol and benzol, it is recommended that consideration be given to the possibilities of additional protection. About this plant there are several copies of the brochure^{CA} prepared by the Barrett Company entitled, "Safety in the Use of Benzol." On the last page, figure four is an illustration of a protective device designed for filling container equipment. Attention is called to this but no recommendation is made. A preference is expressed for an automatic filling system.

Just off the Shellac manufacturing building, there is a room devoted to benzol storage. This room is fitted up with an exhaust system with inlets at the floor level as is desirable. However, this exhaust system operates only when the fan is turned on prior to entry of any person into this room. It is recommended that in addition to the present arrangement where workers are cautioned to turn on the fan before entering, that an additional device automatically cut on the ^{current} floor when the door is open. The reason that this step alone is not regarded as sufficient is that best results will be derived if this fan is turned on and allowed to operate for several minutes, such as five or ten, prior to entry into the room.

The automatic safeguard on the door will merely provide some protection for the workmen who enter the room without a wait period.

e.) In various other portions of this report, reference is made to the testing of the urine of the workers handling benzol, known as the urine-sulphate test. It is now recommended that workers engaged in the manufacture of paint and varnish remover, and particularly the fillers of this product, be subjected to this test from time to time for the purpose of making sure that they are not absorbing benzol. Details of this test may be obtained from the Medical Department. Also it is recommended that workers emptying tank cars of benzol or otherwise exposed to benzol in this department be subjected to this same test which is harmless and which is well nigh infallible in proving that benzol exposure does or does not take place.

In going back to building 23, some comment is made about the process connected with enamel manufacture. This building is the best one devoted to paint manufacture, and while nearly 20 years old this building stands out in favorable contrast to the ancient buildings, 18 and 21.

a.) In this building the single toilets on several floors represent mere cubicles without any roof, thus exposing workers in the vicinity of the toilet to the offensive aspects of toilet use. It is regarded as much more desirable that these illegal (?) toilets be abandoned and that an adequate central toilet room with urinals, locker and wash facilities be created in this building.

b.) On the top floor much dust is created almost continuously due to the dumping of dry materials into mixers with openings at the floor level. These dry materials include a variety of leads, some silica, some silicates, and possibly asbestos. More on account of lead than anything else it is recommended that workers be furnished with respirators for continuous wearing, or, if not continuous, certainly when lead is being manipulated.

In the penthouse of this building--the fifth floor--a battery of large storage tanks is located. These are not equipped with carbon dioxide

overblankets. Owing to the fact that these materials are heavier oils, such as Chinawood oil, etc., the likelihood of fire or explosion from benzol, toluol, alcohols, etc., is not great. No less, the question is raised as to the desirability of carbon dioxide blankets. The chief hygienic concern in this connection is the keeping of the tanks so clean that necessity of entering the tanks or of carrying on extensive cleanup work from the outside is largely obviated.

As a general procedure throughout this plant and particularly in the Paint Department, the tendency is to make use of pulp material rather than dry material. At once this appreciably lessens the dust content in the atmosphere of these departments. Of course, it may be argued that any such step merely removes the handling of dusty materials to other departments. This criticism is not valid owing to the fact that mixing and grinding departments carry out their operations on such a large scale that extensive protective equipment is practical. On the other hand, adequate protective equipment connected with 100 or 500 small mixing machines would not be practical. Thus the use of pulp material is marked with definite approval from the point of view of hygiene.

COMMENT AND RECOMMENDATION FOR VARNISH DEPARTMENT

Owing to the fact that a new varnish plant particularly designed for the manufacture of synthetic resins is in the course of construction, it is unnecessary to make extensive comment upon a series of operations, a great number of which shortly will be transferred to this new building. On this account, comment in this department is thoroughly curtailed.

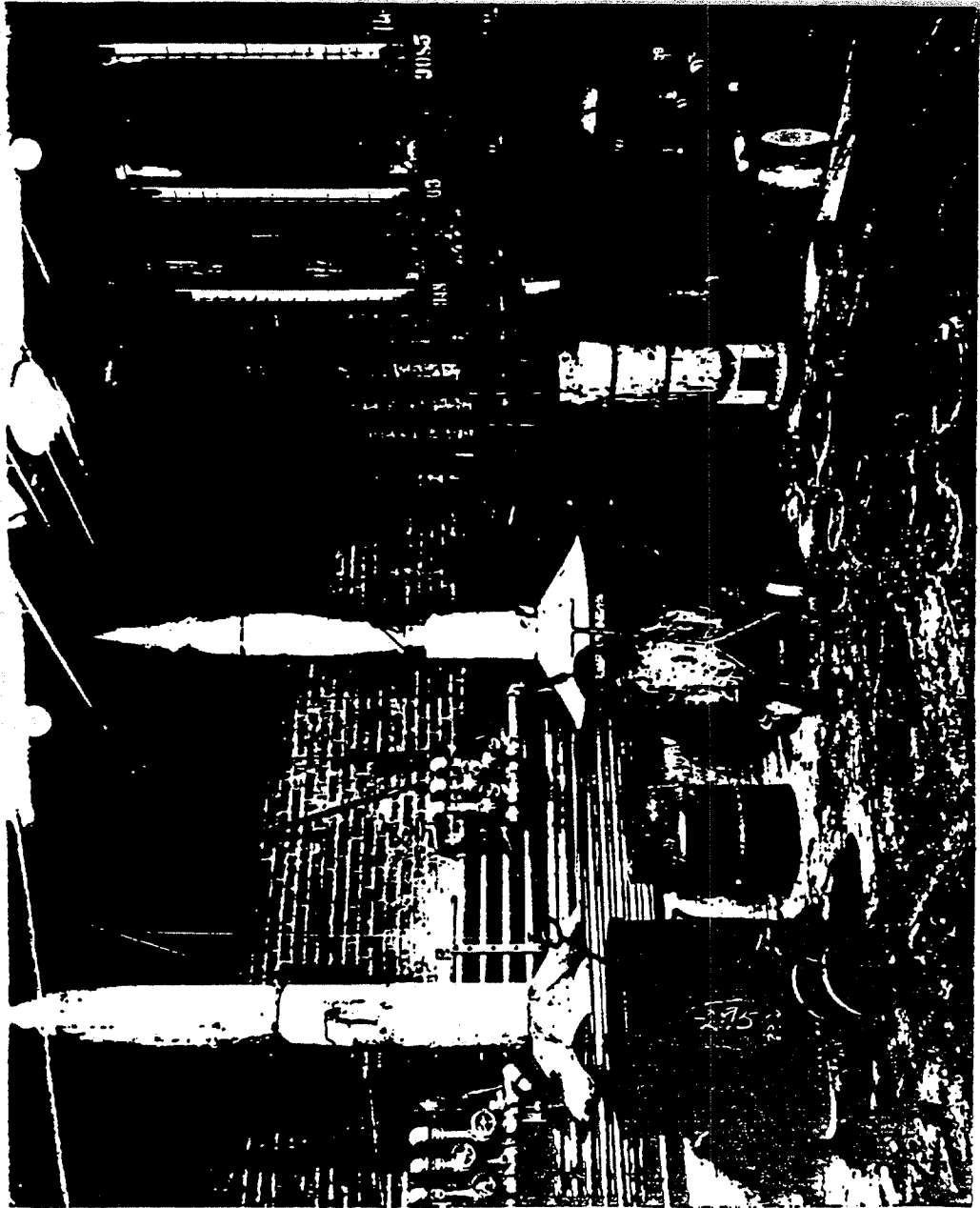
The chief operation not to be moved to the new building is that of blowing oils such as fish oil, linseed oil, etc. When this operation is carried out there is produced at least one and perhaps a series of highly irritant substances in the class of aldehyde; a chief irritant being acrolein or acrylic aldehyde. Whenever fish oil is being blown, the irritant fume produced affects the majority of workers in the department, many workers in other departments of this plant, and may spread over the entire community. It is not unusual that fumes from this operation prove to be offensive to residents a mile or more away from the point of origin.

a.) The present system of entraining these vapors is not satisfactory. The department management already has plans to make use of the Mahon system of water baffles for disposing of this nuisance. In view of the fact that some public liability may exist, in view of the disturbance to workers in this plant, and particularly in view of the item which follows this one, it is urged that rather prompt action be inaugurated seeking the abatement of this disturbance.

b.) For some time it has been known or suspected that varnish workers present a high incidence of pterygium. This condition is an eye disease characterized by the growth over the front of the eye of a scar-like membrane. It occurs both in and out of industry, but varnish workers appear to be unusually prone to this disease. At the Acme plant of this company, two cases were known to exist in the varnish department but the other workers were not examined so that the total number was not

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Vernish Thinning. Thinning Materials are Potentially
Dangerous, Requiring that this Operation be Associated
with Exhaust Systems

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determined. At this plant, casual observation of about 50 percent of the work group established ² (possibly only one) two cases which were very clear-cut. These were accepted as of occupational origin, but it is here observed that one of the men examined is obviously suffering from some other eye affliction unrelated to pterygium. The finding of even two cases of a serious eye affliction lends much support to the contention made in the preceding item. However, it is possible that this pterygium was not caused by acrolein originating in the blowing of fish oil, but instead might possibly be attributed to phthalic anhydride, or to the action of naphtha or some other solvent or thinner.

c.) The stack action in the varnish hall at this plant is especially poor. . However, on representation that varnish cooking will be transferred within a few months to the new building, no stand is taken against this deficiency.

d.) A fair amount of complaint is voiced against phthalic anhydride as utilized in varnish manufacture. This agent affects the workers of the department, other workers in the plant depending upon the wind direction, and conceivably residents and workers in other factories in this neighborhood. Here again no justification for condemning of present operation exists owing to the prospective removal of this entire operation to the new plant where an entirely different system of handling this irritant will be inaugurated.

e.) In the same manner, various other objectionable features connected with the varnish work might be pointed out only to be followed with the statement that automatically these wrongs will be taken care of or that there is promise of their being taken care of in the new department. On this account, no additional comment is made.

Turpentine House

Two small sections of work serving many departments of this plant function under the Paint, Varnish and Lacquer Department. These are, namely, the Turpentine House, the Acetic Acid House.

The turpentine that is here purified is a by-product derived from the Southern states, and presumably is of the steam distilled varieties obtained from pine. This turpentine is characterized by a highly offensive odor around the plant. The operation which takes place is designed to remove this odor. This is accompanied by treatment with calcium hypo chlorite. This material in turn is produced by treatment ^{of} ~~with~~ lime ^{by} ~~and~~ liquid chlorine in a open vat. Minor odors of chlorine are given off, but no complaints have been encountered. Following this treatment, distillation takes place, and the purified turpentine is packed in various containers. The chief source of concern in this entire plant is that of explosion of chlorine. Very large cylinders of this material are located on platforms in open areas between buildings. A large number of 2000 pound cylinders are present. At the present time these cylinders are so situated that they may be flooded with water during the hot weather. These cylinders are equipped with safety blow out plugs, but if one were to give way under increased pressure due to heat, a major disaster might arise. Primarily this matter is one of safety rather than that of industrial disease or one of hygiene. Also it is recognized that the producer of chlorine is well instructed of the dangers in the storage of chlorine. It is therefore recommended that this company fully assure itself ^{as} to the safety of present methods of storing chlorine. If there be any doubt as to the situation, chlorine should be placed underground and under cover or at least so situated that no possibility will exist of a wholesale massacre due to chlorine poisoning. It is understood that this is no new problem to the company, and that plans have been drawn and are possibly beyond that stage whereby the dangers of this situation will be nullified by the placing of these cylinders under cover.

Acetic Acid Section

This small operation is chiefly devoted to the diluting of acetic acid to various strengths and the collecting of the acid in various containers for shipment or other uses. In one step in this operation, wooden barrels are coated with molten paraffin. The paraffin gives off one of the most offensive of odors. It chiefly is nauseating rather than injurious. In this connection it is recommended that the paraffin pot be fitted with a suitable hood and exhaust duct. If at all practical, this hood should be so large as to constitute a canopy under which all of the barrel paraffining may be carried out.

Further, it is recommended that a hood, possibly of paraffined wood, be installed over the acetic acid diluting and filling operation. These vapors are the source of considerable complaint from other departments. The use of the hood and exhausting at the top of the building will go far in increasing the comfort of numerous workers whose duties are apart from handling acetic acid.

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COMMENT AND RECOMMENDATIONS FOR THE LACQUER DEPARTMENT

In the making of a variety of tests during the course of this investigation, for the purposes of establishing the degree of safety of work conditions, measurement of harmful substances in the Lacquer Department chiefly was limited to the concentration of inflammable vapors. Without exception, all buildings in which solvents and thinners were manipulated proved to present some areas whereat concentrations were dangerously high. Reference is made to a special section devoted to vapor determinations. After due consideration, the following recommendations or suggestions have been evolved with reference to this department.

1) In the filtering of lacquers along with associated operations, such as the cleaning of filter cloths and filtering machines, high concentrations of vapors are present under conditions that little lend themselves to remedy. It seems that this condition may be best controlled by providing filter press workers with positive pressure respirators. It will not be necessary to provide helmets or complete face pieces, merely those devices that cover the mouth and nose. In the selection of this equipment, due regard must be given to the likelihood that lacquers may dissolve the rubber respirators, hose lines, etc. and also the paint or enamel present on some varieties of respirators. Purchase orders should carefully specify the peculiar requirements of this work. This type of protection will require piped compressed air under slight pressure, free from contaminants and derived from sufficiently remote points to insure an initial supply of air free from toxic materials.

2) A fair amount of benzol is used in the manufacture of lacquers, which benzol appears to be most troublesome in connection with nitrocellulose cutting. At the present time, benzol, as used, is received in drums and is handled in open systems. Now that benzol is manufactured on the premises, and in view of the fact that there are available empty tanks, it is recommended that benzol be used only in an enclosed system, as is now done for certain other diluents and solvents.

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3) In that entire battery of small rooms devoted to nitro-cellulose cutting, filtering, etc. it is recommended that exhaust systems be installed with the inlets for vapors located at the floor level, since these vapors are heavier than air. In this series of small rooms, certain are devoted chiefly to storage. If this be true, venting systems are not required. However, at least three and probably four of these rooms should be equipped with a venting system sufficient to keep the concentration of vapors below the point of threshold danger. In the case of benzol this threshold is near 100 parts per million of air. At the present time, the concentrations may run as high as 10,000 parts per million for short periods.

4) In the absence of installation of an adequate exhaust system in this area, positive pressure respirators, such as mentioned above, in connection with press filtering, should be worn whenever benzol is used as a solvent or otherwise.

5) In Building 544, one of the chief sources of dangerous concentrations of vapors is the free use of thinner in cleaning of utensils. In this building, there may be seen a group of four or five men, busily engaged in cleaning up many buckets, tubs, small tanks, etc. without any protection, making use of free quantities of spent thinner as a cleaning agent. A little later in this discussion a lengthy recommendation is made with reference to cleaning work in general. Reference is made to that subsequent paragraph devoted to that purpose.

6) Throughout this entire department, a widespread source of vapors grows out of the use of thinner for cleaning purposes, not only of utensils, as mentioned above, but for the cleaning of machinery, floors, etc. It seems necessary to admit that some of this use of thinner is necessary for these purposes, but it must be recognized that any such practice provides widespread evaporation surfaces so that high concentrations of dangerous vapors readily are produced. This means that the use of thinner for any cleaning purpose



Panel Board Cleaning Using Recovered Thinner.
The Location of This Type of Operation in Such
Closely Confined Space Invites Disaster, Par-
ticularly During Winter Months.

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should be avoided if possible and if unavoidable, should be limited to the very minimum requisite to the need entailed.

7) Another source of unwarranted vapor concentration in this building is the terminal of the many piped in solvents and thinners. A few leaks are always present and workers in drawing off solvents carelessly cause considerable spillage and drippage.

8) The entire situation on this floor seems to justify the recommendation that some general ventilation here be provided with inlets located near the floor level and that exhaustion take place through vent terminals at least five feet above the roof level.

9) The high concentration of vapors in this section in considerable measure might be eliminated by greater care on the part of all workers in consistently avoiding spillage and leakage. However, even if this were perfectly controlled, the practice of washing containers in this room would still jeopardize the well being of workers so that the need exists for the removal of this operation from the workroom or at least its isolation through the creation of an isolated workroom and the installation of an adequate exhaust system.

10) In this same building (546), much noise is present, but only a portion may be easily eradicated. Some noise is created by overhead drives or mixing machinery, agitators, etc. This cannot easily be brought under control, although some of this noise is due solely to neglected machinery, worn bearings, etc. However, on the floor below, the chief noise is produced by the metal top dating machine. Here the noise is chiefly produced by the dropping of metal on metal. Three-quarters of this noise may be eradicated merely by the use of a chute or other device which will eliminate the dropping of one tin container top on to another in endless succession.

11) Everywhere in this department there are many storage tanks of varying sizes. Some are equipped with carbon dioxide blankets and others are not. The use of these blankets is chiefly against the occurrence of explosion and fire, but from the point of view of health conservation these blankets serve a most useful purpose in that

they render almost entirely unnecessary the entering of tanks for cleaning purposes. On this account, it is recommended that wherever practical, carbon dioxide blankets be installed and utilized.

12) Building 544 is a two-story building, used for the heavy production of lacquers. The second floor is chiefly given over to mixing, while on the first floor divers operations take place, including centrifuging, container filling, container cleaning, etc. It is felt that concentrations of vapors are sufficiently high throughout this section to warrant the installation of general ventilation. It is believed that it was in this building that a recent case of acute intoxication occurred, such as is mentioned in a subsequent portion of this comment. At the time of the last inspection of this department by these investigators, the weather was rainy and a tendency existed for the holding within the building of vapors. The mere remaining in this building for a short period, such as one-half hour, constituted a disagreeable experience. This observation, plus the actual findings of high concentrations of vapors, made by analytical methods, together with complaints casually voiced by workers, has led to the recommendation that extensive induced ventilation be provided for both floor levels of this building.

13) It is noted that the nitrocellulose cutting, lacquer filtering, etc. takes place in this building, but separate discussions are earlier provided covering exposures therein.

14) Buildings 512 and 513 are devoted to stock storage, packing, etc. It is not known that any exposures arise in these buildings.

15) In Building 547, are located the laboratories, together with certain stock and shipping activities. The only comment made in connection with this building is the suggestion that the toilets for ladies on the second floor be provided slightly more ventilation by merely installing the same sort of opening now furnished the men's toilet in this same section. Odors are present in these toilet rooms which will be increased when winter weather forces the closing of

windows.

16) Going now to Building 510, we find the old lacquer building, which is now unsightly, illy kept, offering many difficulties to the procurement of orderliness, good housekeeping, etc. It is here that ball mills are in operation, using colored materials. Here too are manipulated various stains, etc. Unfortunately, this building's interior has been painted black, which contributes to the general disagreeableness of the situation.

These investigators have been advised that plans long have been under way for the remodeling of this building and on this account the operations have in some measure gotten out of hand. It is not known that any warrant exists for tearing down this building, at least these investigators do not profess to possess such building engineering skill as would permit a stand one way or the other. However, the stand is taken that if this building is not to be reconstructed, much may be accomplished by getting rid of much of the obsolete tanks and machinery no longer in use or in prospective use, by painting up the interior with some brighter color, by scaling off the accumulated encrustation on mills, machinery and floors and generally by a higher order of housecleaning.

17) In this Building 510, wood alcohol is used with fair freedom. The pipe line transporting this material possesses a leak under which a bucket collects the leakage. Wood alcohol is so dangerous that to the full extent possible it should be handled only in closed systems. With the installation of new tanks now in process, it will be possible to install covers and hook up the methyl alcohol line, thus providing a substantially closed system.

18) Below, on the first floor, the substances made by the oxidation of wood alcohol should be accorded great care whenever the possibility of vapors being produced exists. This extends to the filling of containers with these materials rich in wood alcohol.

19) In various other plants where lacquer dough is made and nitrocellulose chips are rolled, much difficulty has arisen because of high concentrations of alcoholic vapors. In this

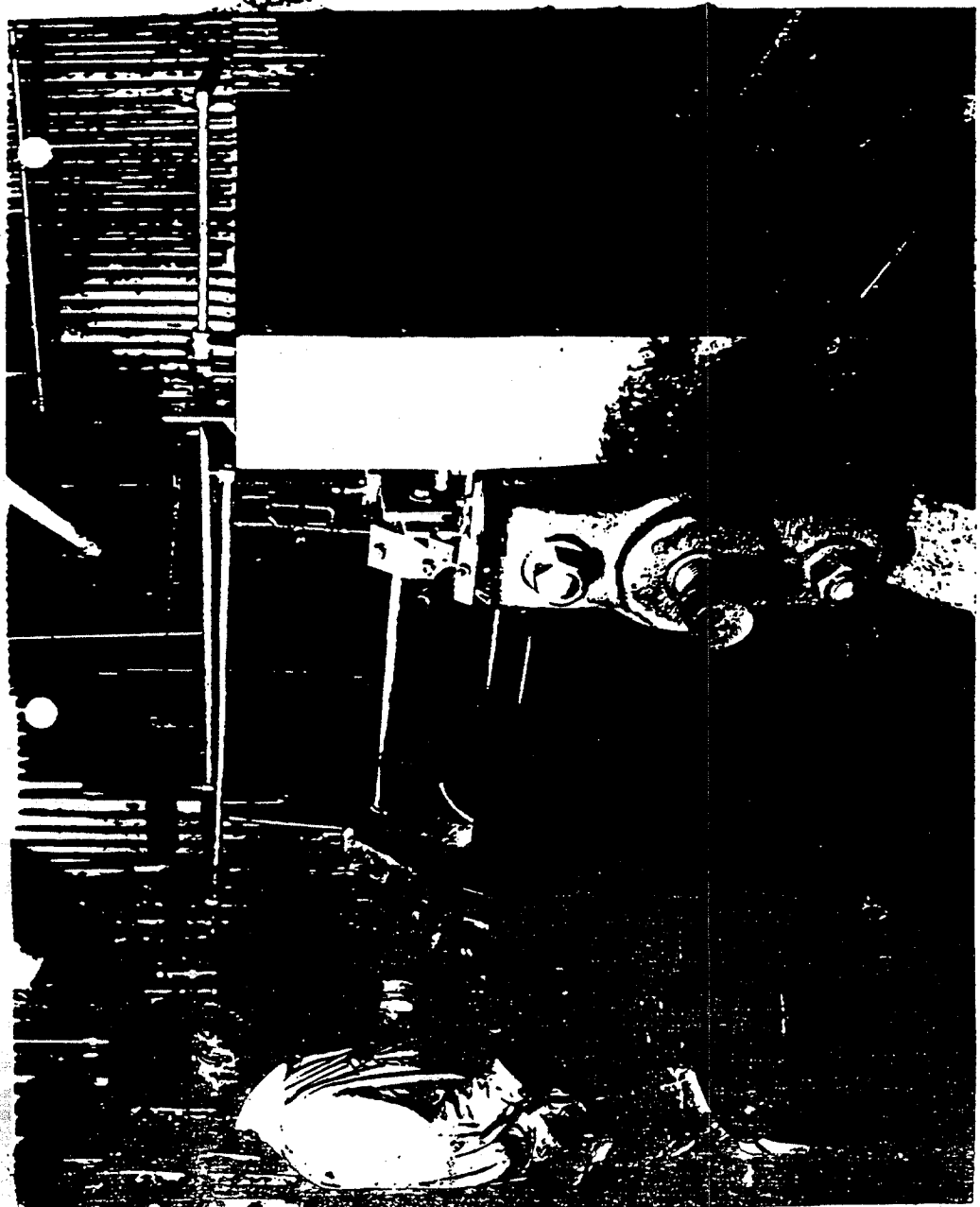


Figure 1. Microcellulose Lacquer Chips. Evaporated
from this operation, in the absence of adequate
protection, introduce possible exposures to fire and to
worker injury

plant, we have not been able to prove that any harmful condition exists so that at least for the present no condemnation is made nor are suggestions for betterment made. However, two considerations are appropriate in connection with this operation, apart from alcohol. The first of these is with reference to vibration in the roll room. These machines are so mounted as to induce an enormous amount of disturbing vibration which may not attract the notice of workmen. No less, this vibration contributes materially to the fatigue connected with this work. If these roll machines may be differently mounted with the result that vibration does not take place or is diminished, this should be done. Secondly, it is noted that at least one of the materials made into dough and later rolled contains antimony (timonox). In view of the fact that antimony is exceedingly toxic, it is urged that workers be furnished respirators for wearing during manipulation of this particular compound, both at the mills, the mixers and in connection with clean-up operations on the machinery and utensils, floors, etc. after each batch is processed.

20) In Building 517, there is carried out a large amount of lacquer drum cleaning, using solvents of little known composition which may vary from week to week. Throughout this report, occasional references have been made to drum cleaning in connection with other departments, such for example as the Coal Tar Products Plant. Always in these earlier items the stand has been taken that in the discussion of this department's drum cleaning, recommendations would be made. It appeals to these investigators that this form of drum cleaning, under conditions prevailing in this building, is pernicious. The workers themselves are aware of a continuous minor affection and further are aware that certain lots of cleaning material sent them are much more harmful than others. This work is being carried out in the open, without any semblance of protection, using such volumes of thinners and such large evaporating surfaces that it is almost inevitable that not all harm may be avoided. Therefore, it is recommended that the management modify or abolish the drum



Lacquer Drum Cleaning, Using Recovered Lacquer Thinner Material and Other Distillates for Cleaning Purposes. High Concentration of Vapors Present in This Workroom. This Operation Is Regarded as Uncommendable as Now Carried Out

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cleaning processes in this plant. Either there should be created an adequate caustic drum cleaning plant, which will act as a central station, including the drum cleaning for the Coal Tar Plant or else these lacquer drums should be sent out, as is now done for other drums, or still else if the lacquer drum cleaning is to continue as at present, an elaborate exhaust system must be created which will tend to provide adequate protection for these workers. In this connection, it is noted that in various buildings of the Lacquer Plant extensive cleaning of smaller utensils takes place with regularity. If all of this work may not be centralized under proper conditions, it will then become advisable to isolate cleaning work of smaller utensils in various workrooms into small rooms, each of which should be equipped with down draft exhaust facilities.

It is realized that this deficiency in the plant's work is well recognized and it has been argued that a saving of from \$15-20,000 a year may be effected by the cleaning of all drums on the premises using the caustic method. In view of the thought earlier given to this situation, no preference is expressed for any one procedure, but the definite stand is taken that the present situation is bad, is conducive to injury and improvement is in order.

21) In Building 570, which is a minor lean-to in the rear of Building 510, a minor operation is carried out involving the cleaning of wood and metal panel boards. This operation should be removed to a more suitable place because of the very close quarters, which provide ample opportunity for exposures to dangerous vapors. As noted in the further discussion of the lacquer situation, one worker in this department is thoroughly disgruntled and while he may be exaggerating to some extent, he has some valid reasons for discontent.

22) In general, the housekeeping in this department is not of high order. Here and there are accumulations of unnecessary rubbish, there is much spillage of lacquer and other coating materials, leaks in pipe lines are neglected, leading to unsightly encrustations. All

in all, it is believed that it will be to the advantage of the department to engage in a higher order of ordinary housekeeping, orderliness, janitor work, etc.

In the course of many trips to this department, a number of notes have been made, some of which directly refer to health conditions in this department. Certain of these notes are now copied as pertinent.

"Investigation of the mixing processes reveals that respirators are not commonly worn and men dump large quantities of dusty materials, some of which have known toxic properties. Improvement has taken place in recent years, it is said, in methods of handling materials in general so as to render work in these locations much more pleasant and probably safer.

One foreman was found to have worked for the past twelve years in this department and he relates how he was tempted to quit many times in the earlier days of the plant because of the many unpleasant and dangerous features present. For example, smoking was not adequately controlled and fires were not uncommon.

It is noted, however, as a minor observation, that machinery in this department is not kept neatly. Large blotches of intermediate materials have accumulated on the surface of mixers, ball mills, etc. The salutary effect of a little paint in illumination and general appearance is demonstrated by the lacquer roll mill plant which has been touched up with aluminum to great advantage.

Odors of turpentine are at times strong, arising from the turpentine distillation unit about 200 feet away. These are very unpleasant at times. Odors of various lacquer solvents are in evidence throughout the plant, at some places being very strong and at others just detectable.

Some employees say that they become dizzy, have headaches, are weakened, grow prematurely tired, and lose their appetites upon first

exposure to these vapors. However, they claim that they "get used to it" after a short time and are no longer troubled. No complaints are elicited with the exception of the worker in the panel cleaning room who is quite disgruntled over his situation, claiming that it could be bettered easily, but that his complaints have been largely ignored. His establishment is merely a lean-to, open under the floor, being raised about four feet above ground level. His floor is of metal and the building small and very crowded. In the summer he has no complaint. In the winter his room is cold partly due to the open space underneath and partly to its metal construction. He must pad it with paper or some other material to a thick depth, and, of course, keep the room fairly closed up while working. He claims that his appetite is lost, that he gets prematurely tired, having to go to bed early at night, not because of the arduousness of his duties, but because of the effect of the fumes. He claims that he is weak, gets headaches and dizziness, and generally feels bad in the winter. He claims that his situation has been reviewed by the management and by the medical department. His panel cleaning is done by hand with a brush in small open vats, over which he stands directly above.

Nitrocellulose storage is in rectangular, elevated, corrugated metal buildings of about 25 feet by 40 feet, just south of the main lacquer buildings. The material is stored in metal drums.

Hand labelers in Building 546 are women who claim that they get dizzy and show other odd symptoms when first starting on their job but become accustomed easily. One of these workers appears to have an abnormal pallor, but does not appear otherwise inadequate to her job. A shellac is used which is thinned by what appears to be a lacquer solvent. This is brushed over considerable areas at one time, and, of course, the worker stands directly over the area.

Heat for various buildings is steam. Ventilation is artificially provided by an overhead exhaust system with branch vents at various

points and a central fan unit of spark proof construction. There are other exhaust fans in use at special points, however. A fair current of air is produced by all these units.

No exhaust hoods over individual operations are in use. It is said that one man about a month ago had a "jag", accompanied by laughing, fainting, etc., while working with a lacquer solvent. Much cleaning of machinery and of receptacles is done using a standard cleaner-remover, or thinner at many points. This is typically done with medium sized brushes, sloshing the solvent over the parts being cleaned. At one point, cleaning of machinery parts is done several times daily in a large vat of solvent whenever colors are changed.

The usual cracking and chapping of the skin of the hands is noted especially in winter on those using the various solvents. However, effort is made to combat this tendency by the use of the "Protek" a DuPont product called the invisible glove which is said to be largely glycerin, soap and water and can be made cheaply. Also a Flaxsoap and thinner combination is used in the washrooms of the lacquer department for its lacquer solvent and detergent qualities. This is said to give no trouble to the skin and to serve very well for the purpose intended. It evaporates readily from the skin on trial, leaving a filmy deposit and a leathery feeling. At first there is an aromatic odor which disappears shortly in evaporating, leaving a soapy odor. A lather can be produced.

The base lacquer cells along the east wall of Building 544 are of great interest because of the strong vapors arising from the solution process. Large quantities of solvent are dumped in from drums through a manhole into agitators below. At times the odors are extremely strong. Some are pleasant and some are quite irritating and unpleasant."

COMMENT AND RECOMMENDATION FOR DRY COLOR DEPARTMENT

The period of this investigation is an unfortunate one for appraising dry color manufacturing conditions as they exist at this immediate time. This situation is due to the fact that this plant is being extensively enlarged through the building of a large new structure, four stories in height, the acquisition of building 119 for manufacturing purposes, the moving of the Factory Offices to building 531, the extension of manufacturing process to a new building between 110 and 111, and the freeing of building 110 for general utility purposes of this department. Thus it is necessary to appraise this department not in terms of immediate conditions but in terms of a very much improved state which will exist from about this time and thereafter.

This acquisition of new space at once tends to meet the prime complaint that might be made by the industrial hygienist against this department, namely, the excessive congestion of work leading to needlessly high concentration of damaging materials being introduced into the air. Restated, this is meant to convey the concept that most intoxicants are almost inevitably in this department because of overlapping of exposures. Deconcentration of work operation is especially desirable in order to escape a multiplicity of exposures. Notwithstanding much improvement, this discussion is not intended to entirely free this department from some charge of excessive work congestion.

Now, building by building, comment is made upon those conditions recognized as exceptionally good and praiseworthy and conversely, those which call for improvement. At all times, stress is placed upon the objectionable conditions rather than upon those conditions that appear to be free from causes of damage.

For building 115--the new Service building--nothing but praise may be extended. Other sections of this report refer to feeding facilities for workers in all portions of the plant including this new building. Provision of an eating room where workers may consume brought-in lunches is

highly desirable. Workers bringing their lunches very definitely should be encouraged to wash thoroughly hands, arms, and faces before the consumption of food. It, of course, would be preferable if they changed garments, but it is believed that this suggestion is not a practical one. It is observed that workers are given two uniforms daily, including underwear. Obviously, some workmen will change ^{these} underwear at odd times in case they become definitely soiled. However, it would be highly commendable for workmen to change uniforms and bathe just prior to the consumption of their lunches. While this may not be made an invariable rule, the possibility of this practice should be studied and, if possible, should be encouraged and enforced.

The only unfavorable criticism is a minor one, and it has to do with the possibility of slipping on the floors of the shower room. This possibility has not been proved, but it may become necessary to put rubber mats or wooden grids or some other material about this floor to minimize the likelihood of falls.

Building 119 apparently has long been used by the Dry Color Department chiefly for storage purposes. It is now being transformed into a manufacturing section. It is most pleasing to see clean machinery operating in surroundings not grossly covered with accumulations of paint, pigment, etc. It is inevitable that this building in time will become less attractive and pleasing. No less, it is emphasized that the way to keep the building and machinery clean is never to permit it to become thoroughly dirty. Day by day minimum cleaning will go far to prevent general unsightliness such as marks buildings 19 and 21 of the Paint Department. At this time there are no objectionable features from a sanitary point of view in building 119.

On the fourth floor off of building 112, there are two rooms devoted to the manufacture of lead acetate. Pig lead is heated up in a retort using coke fuel. This molten lead is allowed to drip into stringy, spongy masses which later are treated with acetic acid, yielding lead acetate. This form of metallic lead apparently yields little or no dust although the dross from the lead pot may give rise to considerable lead oxide. No workers are regularly employed in this department. Notwith-

standing, it is recommended that a doorway close off this portion from the main portion of this level. At the present time it is believed that no door is provided.

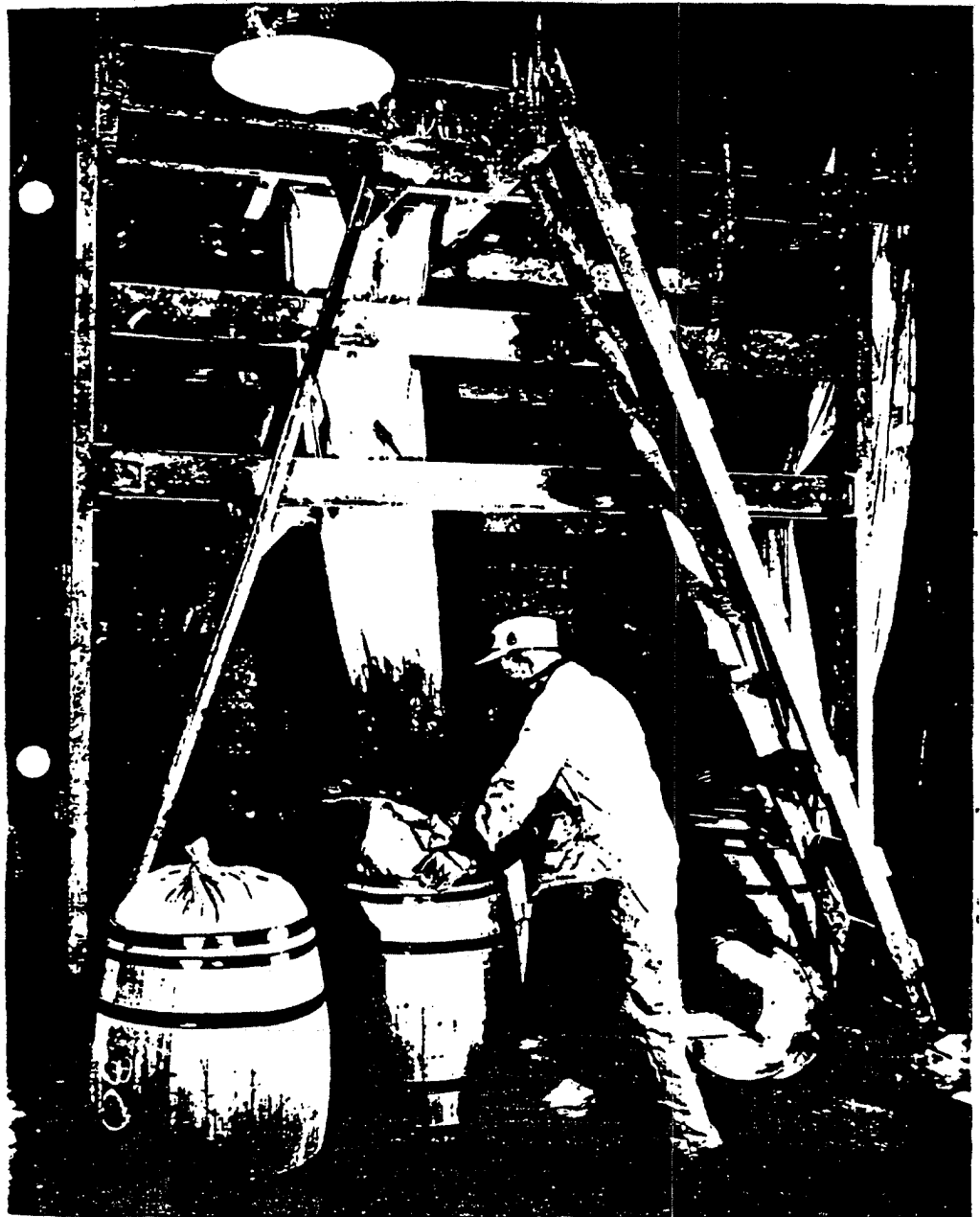
In an adjoining room, the acetic acid dripping in the lead gives rise to disturbing but not necessarily harmful acetic acid vapors. No workers remain long in this room. These slender tanks extend down to the ground floor where lead acetate is removed and stored as a liquid. This area is definitely unsightly, wet, grumous, and calls for extensive house cleaning. It is not known that any portion of the operation connected with lead acetate manufacture calls for the wearing of respirators either for protection against lead or acetic acid.

On the third floor of buildings 111 and 112, together with a semi-fourth floor to building 112, there are inaugurated a series of operations which eventuatedⁱⁿ the production of both organic and inorganic pigment materials. It is here that the basic and intermediate products are handled in their most dangerous form, namely, when dry, and usually in the form of dust bearing materials. Here may be found lead, chromates, (chiefly, however, in solution, but a limited quantity of potassium chromate,) para nitraniline, ortho chlor para, para chlor ortho nitraniline, aceto acetanilin, beta naphthol, meta nitro toluidine, and others, including alkali caustics. Here also, great quantities of mineral acids are manipulated. While many of these substances are highly dangerous on a potential basis, practical harm does not arise in actual experience. One reason for this good experience grows out of the fact that most of these operations are carried out under conditions of low temperature. Many of them are regularly iced in order to bring about temperatures well below 50 degrees. On this account, practically no vapors or gases are evolved, and many otherwise harmless substances bring about no ill effects. A second reason for the good experience is the fact that the majority of those dry substances, such as para nitraniline, are in the form of comparatively large crystals so that actual dustiness is little produced. The third and most important reason is that in the handling of these dry,

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Barrel Filling with Dry Color Material. Highly Dusty
Operation Leading to Extensive Potential Exposures

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toxic substances, respirators are fairly consistently worn. The general circumstances on this floor warrant few recommendations. The most important is that the method of handling mineral acids, and particularly nitric acid, be altered. At the present time, carboys of concentrated acid are entirely manipulated by hand and particularly in connection with emptying into tubs or vats. There are available many devices for hoisting, tilting, and emptying carboys which practically free the operation from danger. It is conceivable that this acid might be discharged through glass lined or other type of piping system. At the present time the situation is highly hazardous, partly because of the bad condition of the carboys and other containers, and partly intrinsically so. Under these conditions, accidents are not improbable. In fact, during the past three months, three acid accidents have taken place. Therefore, it is recommended that the management take early action with reference to this practical problem.

In addition to the mechanical equipment above recommended, it is now suggested that there be installed a safety shower in order that acid wetted workmen may be flushed with water which is the most desirable of all first aid treatments.

Throughout this section, more rather than less furnishing and wearing of respirators should take place. At the present time, it is observed that some operators rather faithfully wear respirators while others do not. Also, it is observed that certain operators wear the "Comfo" respirator while others wear the single filter Wilson type of respirator. Preference is expressed for the former because of the greater breathing area provided and consequent greater comfort to the wearer. Another section of this report refers to the servicing and wearing of respirators.

On this level, projecting from the roof of nearby buildings are two exhaust points for ventilating systems. The first merely is a blower evacuating hot air from around the drying ovens from the floor below. In view of the fact that no large quantity of dust is evacuated by this system, it is believed that the location of this may not be condemned. However, it would be preferable that this outfit be elevated at least to the level of the nearby roof rather than evacuating the dust-containing air immediately in the vicinity of another work air. The second exhaust point is on the roof of building 113 but on the level of the section under discussion. Here large volumes of lead chromate, or at least green pigment, are discharged into the atmosphere and contribute to the lead contamination so general for this plant. In another section, emphasis has been placed upon the atmospheric contamination with lead and the possibility of leading workers whose employment does not entail exposure to lead. Although mention has been made of the possible liability to residents in this vicinity and workers in other plants, it is here emphasized again. While this exhaust point under discussion is far from the worst offender, and while it alone might not be regarded with apprehension, it does contribute its part to the sum total of general air contamination originating in this plant in its entirety.

On the second floor of these grouped buildings, a number of conditions exist which warrant consideration.

1.) In the striking section the fact that operations are preponderantly wet obviates the probability of dust formation. Here, however, some danger from acid injuries exists which leads to the recommendation in this section also that there be built a safety shower into which workers may dart after accidental contacts with caustic acid.

2.) The drying ovens on this level are chiefly devoted to organic pigments. In the dumping of trays of dry organic pigment, a fair amount of dust is created. By and large these dusts are non-injurious and even only exceptionally produce skin affections. No less, it is recommended that respirators be worn consistently during this operation.

3.) The above statement does not apply to the workroom to the South of the dryer room. Here both organic and inorganic pigments are manipulated. Here may be found a certain exhaust system with hoods over the middle of the room and with intakes above the filling point of the blending machines. Although much air is moved by these exhaust systems, they are of the poorest design, and the intakes of those in the middle of the room are located at just about the least desirable point in order to be effective. In other words, the chief dumping points are on the four corners of the room and the dust collecting systems are located near the center of the room. The hoods over the dumping points of the blenders are a better type but still ineffective. It is recommended that this entire dust entraining system in this room be re-designed with the objective of locating the intakes for dust at the point where dusts are created.

4.) By all means, workers in this room should wear respirators chiefly because of the lead exposure provided. Reference is again made to that other section devoted to respirators and their servicing.

5.) In this room and throughout the dry portion of this entire department, dry sweeping is carried out although there is a pretense of throwing out a little wet sawdust. It is believed that there may be a few places where actual hosing out of dry areas may take place in order to prevent actual dust formation. There are other places where light sprinkling ^{may} take place in connection with sweeping, and still others where more and oilier sawdust may be used to advantage. Present practices constitute dry sweeping which is just one more source of toxic materials in the atmosphere.

6.) Adjoining the major buildings of this department on the east side, are a series of petty buildings apparently represented by numbers 128, 123, 594, and 594 extension. The outstanding operation in these buildings is the manufacture of flushing inks. It is stated that a fair amount of benzol is introduced from drums into these inks which possibly should give rise to the use of safety ^{lamps} ~~lamps~~ in this section just

as they are used in certain other portions of this building. This is not made as a recommendation but as an item of inquiry for the Safety Department. At the time of this investigation the Flushing Ink Division was continually unsightly due to the alteration going on in close proximity. Notwithstanding, it is not felt that this section affords any major problems.

On the first floor of this series of chief buildings of this department, a diversity of operations take place, leading to the following recommendations connected with industrial hygiene. At the west end, numerous filter presses are in use leading to continuous wetness, high humidity, slipperiness. Unevenness of floors leads to puddles of water which, however, seem to be more important to the casual visitor than to the constant workman. Workers in this department wear boots or high galoshes and are not concerned with the water under foot. The question was raised as to the use of wooden grids, but opinion appears to be that these are even more slippery than the concrete floor. This existing wetness and high humidity are undesirable, conducive to a variety of ailments such as arthritis, skin maceration, etc., but this condition is so inherently a part of the operation that no known practical measures may be recommended for rectifying this situation.

It is noted that workmen in filling barrels go about this operation with commendable care. The textile bags where filling is done are introduced well into the barrel, but the oncoming dry material is not permitted to drop into the barrel but into a pocket in the bag

whence it is eased into the barrel under conditions which raise little dust. In this same room barrels are filled with lead and chrome bearing pigments from blenders. Exhaust intakes are located about each hopper. These are of very poor design and are not uniform. The dust entraining points in these several cubicles should be re-located with close proximity to the dust source. The situation at the present time is very bad. In the northwest corner of this floor is located the magnetic separator. Here a wall fan removes considerable quantities of dust merely to the outside of the building and there contaminates the entire area as may be seen by green deposits. This arrangement is quite useless and probably more damaging than helpful. It is recommended that a real dust collector be installed about this magnetic separator, and that the exhaust point be other than at the present time.

Near the west wall of the first floor of building 114, there are two large blenders without any exhaust system. Inasmuch as considerable lead is introduced to the atmosphere in their operation, it is recommended that they be equipped with a suitable dust collecting apparatus.

In order that some basis of understanding may be reached as to why extensive modifications are recommended in the dust collecting system in this department, reference is made to both of two sections dealing respectively with lead analyses which reveal the quantity of lead in the atmosphere of this department, and another entitled "Blood Examination" showing the number of persons apparently absorbing lead. It will appear that there is a greater likelihood of lead exposure in this department than in ^{any} the portion of the lead manufacturing department. Without any hesitancy, much unfavorable criticism is made of lead exposures in this department. No respirators of any type will provide 100 percent of protection. Further, no workman wears his respirator absolutely during his periods of exposure. Under some conditions in this department, five minutes of exposure daily over long periods of time is sufficient to make lead poisoning probable.

In this department use is made of a lot of worn out minor equipment such as one-handled hand trucks, broken down ladders, improvised stair steps, and particularly worn out carbon^Y containers. These things have more to do with the Safety Department than health exposures, but it is impossible to resist the temptation to point out that this claptrap, makeshift type of equipment ^{will} ~~should~~ cause injuries. Now that a fine new building has been created to meet some of the problems of this department, some attention should be paid to the numerous needs for marked improvement in petty hand tools, trucks, carboys, etc., which, at the present time, are in a rather deplorable state of obsolescence.

Various other sections of this report furnish some materials on the operations and progress of problems in this department.

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CHIEF OPERATIONS OF THE CHEMICAL PRODUCTS DEPARTMENT

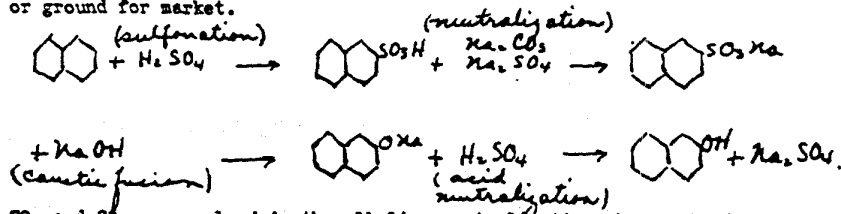
This account of the activities in the Chemical Products Division has been prepared by a physician from the viewpoint of the physician. As gauged by the highly skilled organic chemist, this presentation may be open to unfavorable criticism. The guiding principle in acquiring the information leading to this record has been to uncover every used chemical in the form of raw, intermediate or finished material for which any reason exists for believing that it possesses harmful properties. With this type of information in hand, it has been possible to appraise in various sections of this report the extent of potential and practical dangers for workmen associated with this work:

General Nature of Operations:

Sulfonations, aminations, chlorinations, nitrations, acetylations, fusions, reductions, phenylations, oxidations, condensations, couplings.

Beta Naphthol Process

After refining, crude naphthalene is treated by sulfonation with H_2SO_4 . The sulfonic acid group is then fused off with molten caustic, the beta naphthol is isolated, vacuum distilled and chipped or ground for market.



SO_2 and CO_2 are evolved in the alkaline neutralization above. Most of these processes are wet and so no dust is produced. There is much irritation of nose, throat and eyes in this plant. A good deal of dust is, however, produced in the grinding and packing of beta. Sulfonation is a closed process. Caustic fusion is done in large vats at $315^\circ C$, closed except for a dump hole. The only danger here is said

to be from splashing or explosion. Conceivably Co could be evolved by the burners at times in toxic concentrations.

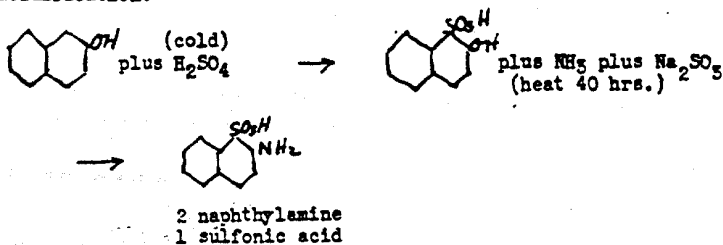
One stack at the neutralizer (acid) has no forced draft and emits clouds of fumes. One man has worked here sixteen years without complaints.

The naphthalene used irritates mucous membranes some, but there is no gross evidence of its having harmed anybody. In its purification, it is washed by water, which carries with it the impurities and is drained off. The washed naphthalene is then distilled, resublimed and stored in the crystals in a special room for use in processing.

Beta goes to the Azo Dye Department for use in coupling of dye manufacture. Some goes to the Tobias Acid Plant for sulfonation and transformation into Tobias Acid. Some goes in ground, purified form to the trade.

Tobias Acid Process

Beta Naphthol is sulfonated under refrigeration by addition of H_2SO_4 and ice. It is then salted out with sodium chloride, filtered through wooden presses and the residue put in barrels. This is then treated with ammonia and sodium bisulfite under pressure for forty hours in an autoclave. This results in beta naphthylamine and formic acid after acidification.



Some SO_2 and NH_3 are released. Tobias is dried, ground and blended. It is shipped to the Azo Department where it is coupled with beta naphthol to make lithol reds. Some goes to the trade.

Tobias is made every day, 48,000 pounds of Tobias Acid are made per month. About thirteen men work on the process. The process from start to finish is about a week long. Most employees have had long time

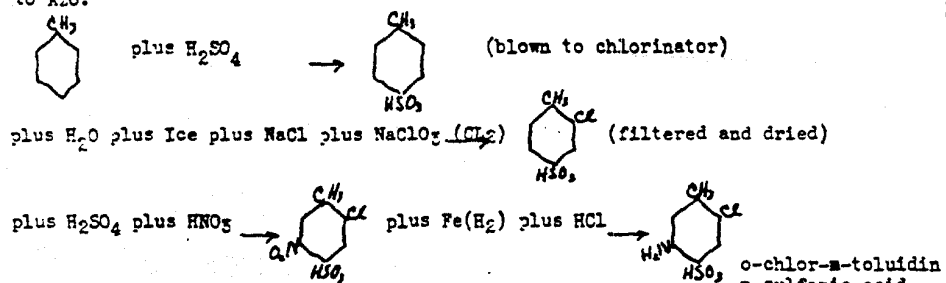


Tobiar Acid Manufacture. Typical of a Large
Series of Chemical Product Operations, All of
Which Are to be Regarded as at Least Potential-
ly and Often Practically Dangerous

service here without gross signs of intoxication from Tobias. SO_2 used to cause "asthma", but not since the installation of vent stacks. The same was true of chlorine. Employees claim great improvement in the safety and healthfulness of the plant in the last few years. Fumes are carried off by stack action, direct to the roof, under forced draft so that when a door is opened into a vessel fumes are not drawn back into the face of the operator. Usual care is used in the use of goggles, respirators, and gloves. The chief irritant to nose and throat is beta naphthol used in this process.

Chlor-Toluidin Sulfonic Acid Process

Toluene is sulfonated in the p-position, then chlorinated in the "o" position, filtered and dried. Then it is nitrated in the 5 position with nitric acid, salted out, filtered and reduced in the presence of iron and hydrochloric to o-chlor m toluidin, p-sulfonic acid. This material is shipped in paste form to the Azo Dye Department to be used in production of Lake Red C. The paste is white, as it goes to Azo.



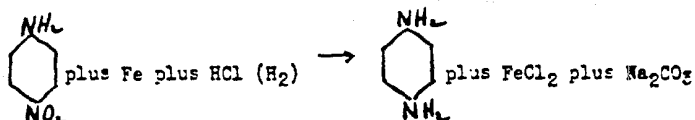
Some chlorine is formed during chlorination. Small amount of hydrogen chloride is formed during nitration. N_2O may be formed during nitration. The process is continuous every day and employs about six men. 16,000 pounds are produced a month. The process is about five days long.

Paraphenylenediamine Process

Paranitraniline is reduced in the presence of iron and hydrochloric acid to paraphenylenediamine. Sodium carbonate is added to form insoluble iron oxide, which is filtered off to leave paraphenylenediamine in solution in the filtrate. This is evaporated and dried in a closed system. Then it is vacuum distilled, recrystallized and packed for shipment in cracked up form. The process is closed except during

filtration and drying of the crude paraphenylenediamine. Drying is done in a mill with forced circulation of air.

It is sold to photographers and to fur dyers. Fur dyers use it with peroxide, brushed on furs, oxidizing the crude paraphenylenediamine to black. Dermatitis occurs in dyers and wearers at times. No trouble has been experienced in this plant.

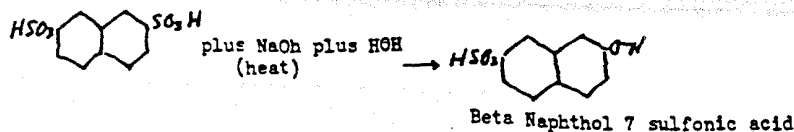


to form insoluble Fe_2O_3 which is filtered off, leaving crude paraphenylenediamine.

Vacuum distillation is done at 170°C under high vacuum; condensation is permitted at 140°C and paraphenylenediamine is solid below that point. It is kept under vacuum until it is solid again. The paranitraniline that is put in at the start of the process of course is a dangerous exposure. Care is used in its handling in the powder form, from drums directly into the reducer vat. About four men are engaged in the paraphenylenediamine production. The process is about two days long. One man in 1935 is said to have gotten "asthma" in the Paraphenylenediamine Department. He is now working in the acetanilid plant. About 12,000 lbs. of paraphenylenediamine are produced per month. It is made every day.

Mono-Acid Process

To 2,7 disulfonic acid, obtained from another department, is added NaOH and water in an autoclave. In the presence of heat, one sulfonic acid is split off and gives beta naphthol 7 sulfonic acid. HCl is added to remove the excess SO_3 . It is then filtered, cooled, filtered again, dried, ground and blended and sold to the Dry Color for use in making dark para toners. It also goes to the trade.





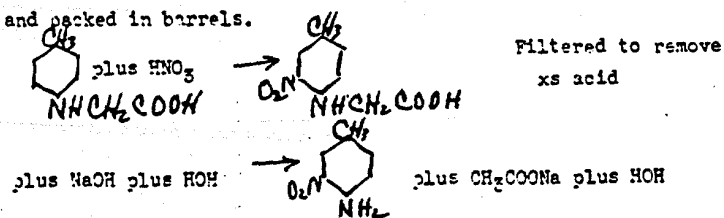
Paraphenylenediamine Manufacture. Both the Raw Materials and the Finished Product of This Type Are Well Known Intoxicants. Definite Dangers Attend This Type of Operation.

0007-SWP-000030643

SO₂ is evolved. 8-12,000 lbs. of mono-acid are made a year. Production is spasmodic, requiring about one day for completion. No men are detailed especially to the process. No trouble has been had from a hygienic standpoint.

Meta-Nitro-Para-Toluidine (MNPT--Toluidin M)

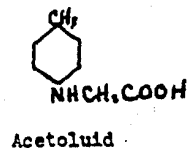
Acetoluid, obtained from the Acetanilid Plant here, is nitrated in the cold to add the NO₂ at the "m" position. Then it is saponified with NaOH and HOH to form M.N.P.T., which is filtered, dried, ground, and packed in barrels.



45° Nitric Acid is used in nitration and sometimes there are fumes. There is a good deal of dust in grinding the material in dried form. In twenty years, manufacturing experience, no bad results have been noted.

Acetanilid Process (and Acetoluid)

Anilin is treated with acetic acid (glacial) in a closed acetylator. Paratoluidine is acetylated similarly to form acetoluid, which is used in the production of Toluidine-M here at the Azo Plant.



Great respect for the toxic properties of anilin is held in this plant. New workers are said to be instructed carefully concerning proper protection, but some-

times are careless until further convinced. One man reached into an anilin tank to recover a wrench, immersing his arm well up in the anilin oil. Luckily, he was intercepted before many minutes, but before he was through his shower he became faint. He recovered in the hospital after about two weeks of a severe case of cyanosis. Cyanosis is said to have been common prior to ten years ago, but rare since. Rubber gloves are used to handle tanks of anilin. It is unloaded through direct pipe lines from tank cars to tank storage in a separate tankage room and thence pumped to its destination. It is not ordinarily allowed to stand open,

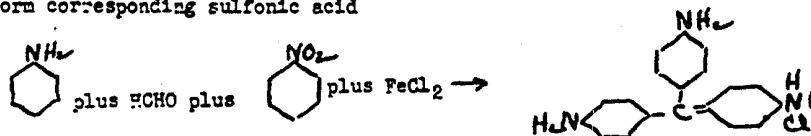
but on recent visits a pan of it was found exposed under a drain line to catch the residue.

Acetanilid dust is carefully guarded against by use of respirators at grinding and packing processes.

Acetoluid is not considered dangerous and is not guarded against. At times there are acetanilid and acetoluid fumes, but these have never caused trouble as far as is known. No trouble with p-toluidin has been experienced since the cans have been emptied through the bottom directly into the hopper at one motion and the lid placed on the hopper immediately after removal of the empty drum.

Fuchsin Process

Anilin is first converted to anhydroformaldehyde anilin, which is isolated. This is converted to diamido-diphenyl methane, which is not isolated. Heated with nitro benzene with ferrous chloride as catalyst, there occurs a complex oxidation and condensation resulting in fuchsin and other by products, the exact structure of none of which is definitely known. Being insoluble, they are thrown out. The resulting hydrochloride is converted to the base. Pararosanilin is treated in the presence of anilin and benzoic acid as a catalyst to form mono, di- or tri-phenyl para rosanilin, which is sulfonated to form corresponding sulfonic acid



p-rosanilin
(tri amino tri phenyl methane)

plus xs of anilin oil, which is recovered and the product purified. Then it is treated further with anilin to form tri phenyl-p rosanilin, which is sulfonated and handled in paste form.

Some of the fuchsin is purified, dried and sold to the market as crystals. Some of the fuchsin base or "milt" is phenylated with anilin to produce spirit blue, which is sulfonated with H_2SO_4 (95%)

to 100% solubility in 1% caustic, blown into water, boiled, cooled to 150°F and pressed, forming crude alkali blue. It is then dissolved in 1% caustic and precipitated with 30% H_2SO_4 . Finished alkali blue is ground and sold as a dry or a wet product.

Victoria blue dye is also produced by tungstination with sodium tungstate, dried, sold as a "dry" or ground with lithol varnish to make crude ink. Methyl violet goes through the same process.

Four chief processes are carried on in this department:

1. Starts with anilin oil and turns out alkali blue.
2. Alkali blue carried on to crude printers' ink.
3. Victoria blue dye is tungstated and either sold as a dry or ground into a printers' ink.
4. Methyl violet same as Victoria blue.

The last two above are called dye "lakes".

Cyanosis: Occasional, one case occurred in August, 1937, in a man cleaning a methyl anilin tub.

Asthma: A few cases occurred before the exhaust stacks were put up.

Deafness: It is noted that men of the fuchsin mill plant where inks are made have defective hearing, apparently from the continuous noise of this mill, which is fairly bad.

Exposures

Large amounts of anilin oil, nitro benzene and formaldehyde are handled in this plant and so are a danger. It is odd that there have been no more cases of intoxication than have occurred.

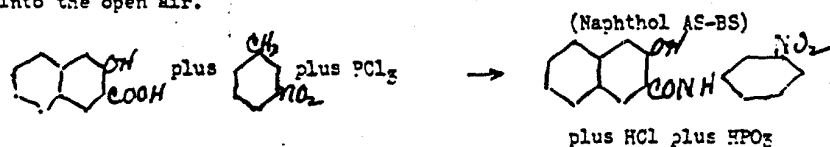
Dry grinding is done to some extent and some dust hazard may exist. Fumes are a notable feature of the process. It is necessary to handle the materials hot, in the liquid form, and so fumes are common. However, most of the processes are closed and tubs and kettles are well exhausted individually through the roof. One large area of hot liquid is exposed while cooling. This is the fuchsin "melt" which hardens in a long, shallow box inside the building. Crude fuchsin is run out hot into a very large metal tank south of the building to crystallize. No known trouble has been experienced in the past with these processes, except as stated above.

At present there is an experimental process going on in the

plant where naphthol AS-BS is being made. This requires the use of PCl_3 , which, being very unstable, evolves much free chlorine if carelessly used in the process. This has happened recently and the plant was so filled with fumes that it was necessary for all workers to leave it. This process is to be put on a commercial basis with new equipment soon, it is said, and the nuisances eliminated. In this same process, in another building, a tub contains m-nitranilin without adequate exhaust. The chemist in charge of the process states that he has suffered vertigo at times over this tub.

This above process consists of a condensation between B-oxy naphthoic acid and m-nitranilin in the presence of PCl_3 and an excess of xylol.

$\text{PCl}_3 \xrightarrow{\text{HOH}} \text{HCl}$ plus HPO_3 . The HPO_3 is probably the irritant to the mucous membranes. Xylol fumes are given off in large quantity into the open air.

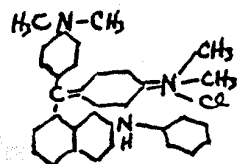


Victoria Blue Production

Raw Materials

1. Victoria blue dye (dry powder)
2. HCl
3. HAc (glacial)
4. Sodium tungstate
5. Sodium molybdate
6. Disodium phosphate

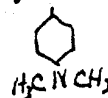
4, 5 and 6 produce phospho-molybdo-tungstic acid. HAc dissolves the "basic" dye which is then precipitated by the complex molecule above.



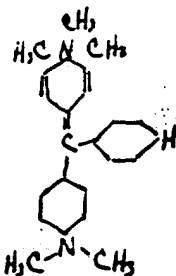
Essentially a carbinol ring substituted with a quinoid structure. The color is produced by the quinoid.

Methyl Violet

Same as above, except naphthalene above is substituted by producing symmetry.



Malachite Green



All raw materials are dry salts except acids. All water soluble. None dusty except raw dye.

Go to printers' inks here.

Tannates

Raw Materials

1. Methyl violet dye (pdr)
2. Quebracho solution (75% tannic acid)
3. NaOH flakes
4. Na_2PO_4
5. Tartar emetic (K An tartrate)

- (a) Methyl violet dissolved in H₂O
(b) Tannin plus NaOH plus Na_2PO_4 plus K An tartrate
a plus b water insol. ppt. of dye.

Tannate dyes go to printers' inks here.

Some dry tungstates are sold as such. Most go to inks.

Resinates--Resin is saponified with NaOH and used in modifying shades.

Production

Made every day: Me-v. tannates, alkali blue, fuchsin.

Made part time: Victoria blue, 3 days a week, methyl violet, 1 day a week, Malachite green, rarely.

Methyl violet is made into tannates and tungstates. Victoria blue and

Malachite green are made into tungstates only.

Fuchsin is an intermediate for alkali blue (chiefly).

Also Dye Department

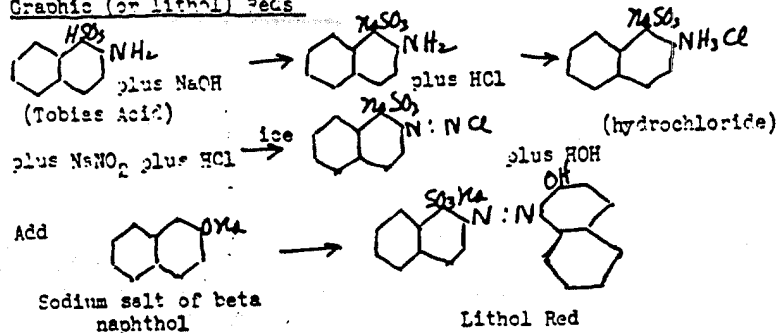
Types of couplings:

1. Toluidic acid is diazotized with nitrous acid and coupled with beta naphthol.
2. p-toluidine m-sulfonic acid diazotized and coupled with b-oxy naphthoic acid.
3. Nylidines diazotized and coupled with B-salt (3,6 di-sulfonic B naphthol).

Colors are produced or converted by sodium, barium, calcium,

strontium, magnesium or manganese salts, then dried, ground and blended.

Graphic (or Lithol) Reds



The color is modified by substituting other of above salts for sodium—e.g. calcium produces a deeper sediment.

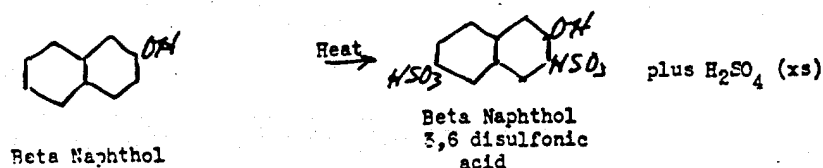
The final product goes to the printing ink trade and much of it is used here in making graphic red inks. A small amount is used in Paint and Varnish for blending.

Exposures:

1. Grinding, blending, packing, drying. A great deal of dust is produced and this theoretically is a danger. However, one man on grinding has done this work for sixteen years and says he is in perfect health.

2. Nitrous Oxide is occasionally evolved from the diazotizing process when carelessly done, but this is not common. This is done in an ice bath and so the amount of fumes is not great. Exhausts are provided for those tubs where fumes and vapors are troublesome.

R-Salt



The whole is run into Ca(OH)₂ below where the xs of CaSO₄ is removed. The R-salt is salted out with NaCl and shipped as a paste. Coupled with xylidines here. No intermediate is formed and no dry material is handled except the beta naphthol as it comes chipped from the beta plant here.

No known exposures.

Lake Red-C

2-chloro 5-diazo toluene 4 sulfonic acid is formed as an intermediate prior to coupling with beta naphthol to form the dyestuff.

Scarlet Red

Same intermediate as above. Coupled with beta naphthoic acid.

Lithol Rubins

Intermediate p toluidine m sulfonic acid before coupling with beta naphthoic acid.

Scarlet 2B

m-xylydine intermediate before coupling with R-salt.

Pigment B Green

Nitroso B naphthol formed as intermediate before converting to iron salt.

General Remarks on Azo

Tylenines are handled. These are known to be toxic. Lead acetate is used in small amounts. BaCl_2 is used in considerable amounts. Beta naphthoic acid used here is toxic to some degree. Nitrous oxide as mentioned above is evolved at times, but has given no trouble. Beta naphthol, supposed to be a skin irritant, has caused no trouble. It is troublesome as a nose and throat irritant, but workers "get used to it".

Remedies for the bad dust situation are underway. Requisitions for new ventilation equipment are under consideration, according to workmen. Workmen state that improvement in the recent past has been continuous and steady. HCl in Azo dye is now handled in rubber pipes from storage instead of being hauled in carboys. Goggles and gloves are used where danger is known. Ice is now broken up by power. Exhaust stacks are in use where needed.

Employees are mostly of long tenure and have been trained into certain jobs so they are really expert in these functions, thus being able to control chemical reactions "on their own" and so avoid side reactions of dangerous or unpleasant character.

Handling of much raw material is still by hand, however, and it strikes one entering as an observer that much of this work should and

could be mechanized to advantage from a health as well as an efficiency standpoint. One sees carboys of acid being dumped by hand and barrels of caustic flakes being shoveled by hand.

Crowding, as in other departments, is severe, and the great amount of hand trucking and moving of materials through narrow passageways must contribute manifestly to fatigue and irritability in workers, and to danger.

Great vats of materials, such as R-salt are lifted by hand in places, thus predisposing to hernia, etc. in workers.

Potentially the metal salts of strontium, barium, calcium, sodium magnesium and manganese, used to produce colors in Azo dyes are hazards.

Two cases of dermatitis have occurred in the last eight years, it is said.

COMMENT AND RECOMMENDATION FOR CHEMICAL PRODUCTS MANUFACTURE

By all odds, this division of this plant's operation provides a greater number of outstanding complex hygienic problems than any other. However, the majority of these problems are so definite that hygienic appraisal is comparatively simple although the finding of a remedy to eliminate the difficulties detected is by no means simple.

From the point of view of hygienic protection, it is the general thesis of this discussion that in this portion of the plant the work is so highly concentrated and overdeveloped in relation to the space available that no perfect remedy may be found. Above all things requisite to health conservation in this department, dilution of work operation stands out as most essential. The further addition of protective equipment such as dust arrestors, safety showers, vacuum cleaning system, all of which would be useful, would but further add to the concentration of work congestion.

It is not within the purview of this study to recommend the building of new buildings or the allotment of other buildings in this area to this department's activities. Instead, it is the prime function of this inquiry to detect and portray objectionable situations wherever they exist and leave to the management decisions as to accepting the portrayals and the finding of remedies.

It is necessary to regard almost every operation as providing potential if not practical exposure to some one or more injurious substances. Recognizing that certain operations in themselves provide no outstanding exposure, these almost invariably are so located as to be placed in proximity to other operations or more dangerous potentialities. Still further, a fair amount of opportunity exists for the injury of workers in adjoining departments or divisions within the same department through the air transportation of effete materials discharged through exhaust systems or otherwise. At least to a theoretical extent, persons not connected with this entire plant but living close to this department or working in nearby establishments might be injured or alleged injury might arise from discharged materials originating in this department.



Beta Naphthol Container Filling. Beta Naphthol
Is Definitely Irritating to Eyes and to Some
Extent to the Respiratory Tract and Skin. Offen-
sive and Discomforting Type of Work Rather Than
Highly Dangerous

Lest there be some unfavorable criticism of this definite language, one example of each is at this time cited in substantiation of the two points last made. First, with reference to injury to workers in another section of this plant's work, attention is called to the fact that the acetanilid exhaust stack terminates above the low roofed acetanilid house but on a level with open windows of another and higher building with only about 20 feet of space intervening. Quite readily, acetanilid dust may be carried across this short distance and into this other department. Secondly, with reference to injury to non-employees, it is noted that a fair amount of stacks, chiefly connected with tobas acid manufacture, are installed for the entraining and discharging of sulphur dioxide. Large volumes of this injurious gas are discharged into the general atmosphere. Only ten parts per million of this gas are necessary to produce minor respiratory tract irritations. Even lower concentration may bring about minor property damage. It would not be unusual for persons residing in that district north of 115 Street to make objection to the presence of this gas in their homes and around their premises. Fortunately, this plant is so isolated as not to be in close proximity to any residence or other work places.

If this report were limited solely to consideration of the hygienic problems of this department, it might be practical to present a detailed discussion of the nature and circumstances of the toxic action of scores of the raw materials, intermediates, and finished products produced in this department. While a great deal of such material is available, it is no less recognized that there are many substances manufactured in this department chiefly as intermediates about which little or nothing is known, and about which statements as to toxicity may be made only through knowledge of similar chemical compounds.

However, all in all, it is deemed undesirable here to present lengthy toxicologic discussions. Running through this report, a few such items appear, but by no means are these furnished as adequately covering the situation. Reference is now made to the series of publications

dealing with toxicity of chemical products related to the dye and pigment industry, but in turn these may be regarded only as introductory.

Encyclopedia of Occupational Health, International Labour Office, Geneva.

Occupational Affections of the Skin, R. Prosser White, H. K. Lewis & Co., Ltd. London, 1934.

Legal Medicine and Toxicology, Peterson, Haines and Webster, W. B. Saunders Co., Philadelphia, 1926.

Industrial Poisons in the United States, Alice Hamilton, Macmillan Company, New York, 1929.

Industrial Toxicology, Alice Hamilton, Harper & Brothers, New York, 1934.

Skin Hazards in American Industry, Louis Schwartz, Public Health Bulletin, No. 229, September 1936, United States Treasury Department.

Noxious Gases, Henderson and Haggard, Chemical Catalog Co., 419 Fourth Avenue, New York, 1927.

Toxicology, William D. McNally, Industrial Medicine, 540 North Michigan Avenue, Chicago, 1937.

Causative Agents and Protective Measures in the Anilin Tumor of the Bladder, E. E. Evans, Journal of Urology, Vol. 38, No. 2, August, 1937.

In general, reference is made to the Journal of Industrial Hygiene and Toxicology, which, through its original papers and its abstracts, furnishes the best compilation of all industrial toxicological papers published through the past 19 years throughout the world.

Now, after this general comment, consideration is given to the individual sections and always with emphasis upon dubious work conditions and suggestions as to remedies thereof. Prior to departmental discussion, it is deemed desirable here to include some excerpts from one of Dr. Hamilton's reports. These excerpts now follow.

So little is known about the toxic properties of the many complex derivatives of coal tar and particularly those used as intermediates in the manufacture of coal tar dyes that it is desirable to make use of all available information. This attitude leads to the inclusion of various sections of Dr. Hamilton's report on coal tar derivatives. These excerpts now follow:

The derivatives of the benzene ring are numerous, they are industrially important and they are extremely complex. New ones are introduced continually, too rapidly to allow the toxicologists to keep pace with the chemists who produce them, and the result is a field more obscure and difficult for the industrial physician than any other. It is sometimes possible to predict from the chemical composition of the simpler members of the coal-tar group what the physiological action will probably be, although even here the problem of the isomers enters, for of three products with the same formula the one in the para position may differ physically and toxicologically from the one in the ortho position and both from the one in the meta position. Resorcin is meta-dihydroxybenzene; hydroquinone is the para compound. The French high explosive, melinite, is a mixture of picric acid, which is trinitrophenol, and dinitrophenol, the latter having the two NO₂ groups and the HO group attached to the ring in the 1-2-4 position. This isomer proved during the war to be highly toxic, with a characteristic action which was not shared by any of the other isomers.

Many other illustrations could be adduced, but these are sufficient to indicate some of the complexities of the subject. When one leaves the simpler intermediates and goes on to the bodies built up from them that are used in industry, one encounters such complicated structures as paraphenylenediamin, para-amido-para-nitranilin, para-amidodiphenylamin, all fur and felt dyes; para-nitrosodimethylanilin, hexamethylenetetramin, anhydroformaldehyde-para-toluidin, which are among the numerous rubber accelerators.

Some of these compounds have been studied by the Germans, and their action has been well known for some time. Even now the Germans are reporting from time to time the results of their tests of newer compounds, the U.S. Public Health Service has tested a few compounds and reports of cases are published in the annual report of the medical inspector of factories in Great Britain. In the United States, it is a regrettable fact that the great dye, drug, and chemical industries have added very little to our knowledge in this field.

Only a brief survey of the most outstanding features can be made here. The relation between chemical constitution and toxicological action is, according to Fraenkel, as follows:

Hydroxy compounds—The phenols and cresols are hydroxy derivatives and the entrance of the HO nucleus renders the naphthols, alpha and beta, more toxic than is naphthalene. Industrially, however, phenol is not nearly so dangerous a poison as benzene, for it is so much less volatile. Severe burns may be caused by phenol or cresol, although even this is not common, but systemic poisoning is almost unknown in industry. McCord reports a case of a woman in a shoe factory who spilled two or three spoonfuls of marker ink over her skin in opening a new bottle and shortly thereafter developed typical systemic phenol poisoning from skin absorption. During the war extensive burns of the skin were not uncommon and there was an occasional case of absorption, with collapse and death.

Chlor compounds.—The entrance of chlorine into an aromatic compound does not increase the toxicity as it does in a fatty compound. In fact chlorobenzene is less toxic than benzene. The nitroso group (NO) and the nitro group (NO₂) always increase toxicity, but there is no rule as to increasing toxicity with an increasing number of nitro groups, for the 1-2-4 isomer of dinitrophenol is much more poisonous than is trinitrophenol (picric acid), and mononitrobenzene is more poisonous to the central nervous system than dinitrobenzene, but the latter has a more destructive action on the blood.

Nitro and amido compounds.—When a nitro compound is reduced to an amido, as when nitrobenzene is reduced to anilin, nitrotoluene to a toluidin, the toxic characteristics remain much the same, but the intensity of the action is lessened (Curschmann). The same thing is true with regard to most of the diamins, the nitranilins, chloranilins, etc. The following description applies to the members of these groups which contain nitrogen, although there are, of course, some exception.

In a light case of poisoning with a nitro or amido compound, the symptoms are at first those of anoxemia because, so it is generally believed, the formation of methemoglobin brings about a condition of internal asphyxia. The symptoms are typical of the latter—a flushed face, pressure in the head, which increases to a violent throbbing headache, with dizziness, weakness in the knees, and more or less dyspnea. In severer cases the face is deeply cyanosed, the lips, tongue and ears are purple; there is nausea, sometimes vomiting, a complaint of cramps in the abdomen, a staggering gait, and extreme weakness. An attack seldom occurs during work, but some time later, and the symptoms increase in intensity. If consciousness is lost it is usually not until some hours after. In the early days of the industry in this country, from 1914 till after the war, severe and fatal cases were seen which were characterized by extreme prostration, the skin cold, the blood pressure low, the pulse very rapid, small, and irregular, the respiration shallow and rapid, then growing slower as death approached, and just before the end, convulsions. In some cases an acute attack has been precipitated apparently by alcoholic drink, not necessarily excessive in amount.

Renshaw and Ashcroft described four cases of poisoning by nitrochlorbenzene and one by acetanilid where there was a destructive action on the blood, increasing gradually, as shown by the fact that the men collapsed some hours after leaving work, the action being apparently hastened by alcoholic drink. The symptoms progressed slowly, first cyanosis and collapse, then, as the destruction of red cells increased, dyspnea became marked and disappeared only as the blood returned to normal. The blood findings consisted in anemia with a high color index, no jaundice, no nucleated red cells, and little change in the morphology of the red cells. Nor was there a pronounced anemia except in one case which had a red-cell count of 5,100,000 with 68 per cent hemoglobin. Practically the same condition was found in a case reported by Arneth and Albacht, where the red cell count was 5,925,000, and the hemoglobin 65 per cent, but there was no change in the white cells. On the other hand, Fenton and Minot both found a marked lymphocytosis and also an increase in the large mononuclears and in the plasma cells. Minot found lymphocytosis in trinitrotoluene poisoning of mild degree, leucopenia in severe cases.

*Acetanilid is less toxic than anilin and, being solid, is less easily absorbed through the skin. It is used in making celluloid, where it can take the place of camphor, and is also an intermediate for coal-tar dyes.

The livid color persists for several days and in chronic poisoning it is plainly evident; indeed, the name given by workmen to anilin or nitrobenzene poisoning is "cyanosis." Usually an acute attack passes over fairly rapidly, especially if it is from an amido compound. Wignall says that if a case of anilin poisoning lingers on he suspects arsenic and tests the urine for it. On the other hand, the nitro compounds give rise to more serious symptoms with slower recovery, although the cyanosis may be less striking.

Curschmann, Lehmann, and Mohr say that methemoglobin is formed early in the course of intoxication and probably the destruction of red blood cells is coincident with it. The red-blood-cell count and the hemoglobin fall, the blood becomes chocolate-colored and thicker, and the spectroscope shows the lines of methemoglobin. However, the latter finding is disputed by some (see Price-Jones and Boycott) and even Curschmann says that methemoglobin disappears very rapidly and usually by the time cyanosis is fully developed it can no longer be demonstrated.

The destruction of the red blood cells is followed in a few days by evidence of regeneration, in the form of immature cells, many of which may be stippled and nucleated. According to Hudson, there is at first a polynucleosis followed later by a lymphocytosis. The urine in anilin poisoning may contain unchanged anilin (Neubauer, Mollerstrom,) but this is very rare. Much more common is hematoporphyrin or bile pigments, and some observers speak of a substance, as yet unidentified, which reduces Fehling's solution. A reduction compound appears in the urine, even in milder cases of poisoning, such as para-amidophenol from anilin, the nitrobenzenes and the nitranilins; amido-2-nitro-4-phenol from dinitrophenol; dinitro-hydroxylaminotoluene from trinitrotoluene. This is probably the explanation for the bladder symptoms which are characteristic of cases of poisoning from these derivatives of the benzene ring.

Unusual effects.—Although this description covers the majority of nitro and amido derivatives, there are some conspicuous exceptions and probably if other compounds were as extensively used and studied other exceptions would come to light. These are some instances of compounds which have an action deviating from the typical: dinitrobenzene, which in chronic cases produces profound cachexia, mental deterioration, paralyzes and impairment of sight, smell, taste, and hearing (Floret, Cords; trinitrotoluene, which causes in some cases acute yellow atrophy of the liver, toxic jaundice, in others aplastic anemia; toluylenediamin, a powerful hemolytic agent; dinitrophenol 1-2-4, which causes an acute intoxication with burning thirst, abundant sweat, panting, terrified excitement, fever up to 109.4° F., convulsions and death ((298), (470)); and finally a fairly large group of amido compounds which have an irritating action on the bladder, leading not only to cystitis, but to papillary growths and even carcinoma.

Bladder tumors.—Cystitis may follow exposure to such compounds as alpha and beta naphthol, but bladder tumors are apparently caused only by an amido compound. The occurrence of these tumors, benign and malignant, among workers engaged in the production of dye and drug intermediates, has been known to German physicians for more than thirty years, and in 1904 the physicians attached to the large plants began to collect and report their cases so that there is now a large body of data available on this subject. In 1920, when Curschmann published the collected statistics, there were records of 177 cases. Since then I have seen no summary of the cases, but each year the factory-inspection report adds a number to the list, and during the three years, 1927-29, there were 19 new cases of malignant tumor. The English also are now beginning to find this evidence of chronic poisoning among workers in their industry, which is of much more recent development than the German (Wignall).

A wide variety of compounds may give rise to bladder tumor, but it is the consensus of opinion so far that the compound responsible is always an amido, not a nitro compound, although in other respects the latter is the more toxic group. An interesting case is to be found in the German factory inspection report for 1929. A man who had worked six years with trinitrotoluene died of cancer of the bladder, and compensation was at first refused on the ground that nitro compounds have never been known to produce such cancers. Further consideration of the case, however, resulted in a reversal of the verdict on the ground that trinitrotoluene is excreted in the urine not as such but as an amido derivative.

Para-phenylenediamin--sometimes called diamino benzene. Cases of poisoning from paraphenylenediamin are comparatively numerous and are reported even in the non-industrial journals because they occur in persons wearing fur dyed with this compound. It is a much-used dye for fur and felt, the trade name being ursol, and is also an accelerator for rubber vulcanization. It has a very characteristic action, causing severe dermatitis, and in some cases attacks of bronchial asthma which, according to Hanzlik, is to be explained by an acute edema of the bronchial tubes (R. L. Mayer). Mayer and Foerster examined 181 persons employed in the fur trade where ursol was used as a dye and found that 111 had suffered from dermatitis or asthma. They advise using the skin test on new men, to weed out susceptibles. Diphenylamine and para-amido-diphenyl are used in industry. They have the action characteristic of amido compounds, and like the rest, they are absorbed chiefly through the skin.

Toluidin.--The toluidins are important intermediates and are responsible for cases reported by both English and German factory inspectors. In both countries cases have arisen in connection with chlor-ortho-toluidin, which is said to cause symptoms of acute nephritis; according to the Germans, however, it is not the men using it but those producing it who are poisoned, suggesting that the cause is some intermediate. Eight German girls applying dope consisting of resin and oil dissolved in chlor-toluidin showed striking pallor, with cyanosis of lips and finger tips, and complained of dizziness, headache, fatigue, anorexia, nausea, and an imperative desire to urinate and burning pain on micturition. The urine was reddish and in four cases blood was found, showing a hemorrhagic cystitis. The blood showed polynuclear leucopenia, and eosinophilia, and in two cases there was methemoglobin.

Anilin black.--Anilin black is made by the oxidation of an anilin salt by means of chlorate or bichromate of soda in the presence of a metallic catalyst. The chemical action is complicated and the dyeing takes place with the aid of steam and requires aging or ripening. Anilin vapors are given off during the process, and if the fumes escape, poisoning occurs. Cases from this source, quite typical in character, are reported each year from Germany and from England. The complaint is greater in warm weather or on foggy days in winter. An examination of the blood of 39 workmen showed in a few some evidence of destruction of red cells and a lymphocytosis, but in healthy men with only moderate exposure the blood count was sometimes over 5,000,000.

The following compounds were responsible for 95 cases reported by the British factory inspectors in the years 1927-28 and 1929: 41 from the intermediates dinitrobenzene, dinitrotoluene and trinitrotoluene; 18 from anilin; 7 from dyeing with anilin black; 15 from production and use of other anilin colors; 9 from para-nitranilin; 8 from paratoluidin; and 7 from all others. The list of compounds which gave rise to poisoning in these years in the Swiss chemical and dye industries is as follows: dinitrobenzene, dinitrochlorbenzene, anilin, para-nitranilin, para-chloranilin, para-toluidin, nitrosodimethylanilin, beta-naphthylamin, mono-nitrobenzene, dimethyl sulphate, anthracene.

Naphthalene fumes may cause headache, nausea, and vomiting, and, if hot and concentrated, not only injury to the corneal epithelium but a double optic neuritis (Koelsch). Perna, perchloronaphthalene, is used in Germany as a substitute for gums and resins in impregnating textiles, in which work it has been the cause of skin eruptions and general malaise, a feeling of weakness and uncertain gait. Tetralin, tetrahydronaphthalene, is used in this country as well as in Germany as a degreaser and as a substitute for turpentine, especially in floor finishes. The vapors are irritating to the mucous membranes and conjunctiva and also cause nausea, headache, and stupor. A dark, olive-green coloration of the urine is characteristic of this form of poisoning and it is attributed to the hydrolysis of tetralin to tetralol, which is excreted as conjugated glycuronic acid (Koelsch).

All of these poisons, derived from the benzene ring, are absorbed through the skin primarily. It is true that the inhalation of fumes is a possible mode of poisoning but experience in all the warring countries proved beyond the possibility of a doubt that the skin is by far the most important portal of entry. This means that bodily cleanliness is the first requirement in the prevention of poisoning. There must be scrupulous cleanliness of benches, machinery, apparatus, and there must be provision for bathing with warm water as well as for washing hands and face. In well-equipped plants tub baths are provided and acetic acid is added to the water to aid in the removal of these oily compounds. It is the rule in plants under experienced direction that a man who complains of feeling ill be directed to take a full bath at once and put on clean clothing, underwear as well as outer clothing, even if he feels sure that he has not spilled anything on his person.

The escape of fumes must not be neglected, for volatilized compounds solidify as they cool and fall in the form of fine powder over the skin. Hot weather always increases the number of cases of poisoning in these industries because the sweat helps to dissolve the dust on the skin and flushing of the surface vessels helps in its absorption. Dirty overalls and, still more, dirty underwear, are a distinct menace, and a careful employer will provide clean washable working-clothes for his men, as he is required to do in England and in Germany.

THE TOXICITY OF BETA-NAPHTHOL

Because of the varied and extensive operations connected with beta-naphthol and because of many casual complaints about its irritant properties, these investigators have thought to bring together all that is known about the toxic properties of beta-naphthol. This compiled material now follows:

Beta-naphthol may be classed as a phenol and is a hydroxy (OH) derivative of naphthalene. The compound resembles phenol in its toxic action but is not nearly as irritating. Since an increase in hydroxy (OH) groups increases toxicity, beta-naphthol is more toxic than naphthalene.

In spite of its decidedly dangerous nature, very little research work in the form of animal experiments have been done. Although beta-naphthol has a great many uses in a large variety of industries, it has given rise to very little trouble in the past. From a chemical standpoint this is partly due to its relatively high melting and boiling points. Under manufacturing conditions the compound is seldom if ever heated to near its boiling point, thus reducing the possibility of expelling its vapors into the workroom air. Actually there is little contact on the part of workmen unless in the case of an accident.

Aside from the many industrial uses of beta-naphthol it has been used to a considerable extent in the past in medicine and many cases of poisoning have occurred from its use. The compound was originally used in China and later in the United States for the treatment of hookworm. It has also been used in ointment (5-10% beta-naphthol) for the treatment of various forms of skin diseases. Its use as an intestinal disinfectant has been discontinued to a large extent because of its relatively low efficiency and its severe toxic action upon the human body. Although many cases of poisoning have occurred from the use of beta-naphthol in the treatment of skin diseases, its use is still continued.

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As stated above, research work on the physiological action of beta-naphthol has not been extensive; however, there are a large number of cases reported of the poisoning from its industrial and therapeutic use. A summary of these cases indicates that its toxic manifestations vary considerably in different individuals. As a matter of illustration, two cases of poisoning are here discussed. The first case is that of a man who had been treated with nearly 15 grams of beta-naphthol for a skin disease. The only apparent toxic effect was acute nephritis after 14 days. The second case was that of a pregnant woman who had been treated with 3-5/4 grams of a similar ointment. In this case, the woman died 24 hours after the application and experienced such symptoms as vomiting, somnolence, unconsciousness, and later small hemorrhages from the skin.

Beta-naphthol is irritating to the mucous membranes when it comes in contact with them in solution, vapor or mist. Because of this fact, it causes sneezing and coughing when it comes in contact with the respiratory passages and in the course of excretion, produces pain in the bladder and urethra with strangury and swelling of the mucous membranes. In large doses, beta-naphthol causes symptoms similar to phenol poisoning, except that in animals, no convulsions have been observed. When injected subcutaneously, albumine and hemoglobin in the urine have been noted. Therapeutic injection of beta-naphthol has produced severe anemia due to its action on the red blood cells and icterus resulted.

In excessive quantities, beta-naphthol produces epigastric and diffuse abdominal pain, nausea, vomiting diarrhea, muscle spasm, depression of the respiratory center, and at times hemolysis, convulsions, respiratory and cardiac paralysis, and coma. There is frequently a scarcity of urine with painful micturation. The urine is usually dark brown from the presence of the naphthol which is excreted in combination with glycuronic and sulphuric acids. In less severe cases of the poisoning the symptoms may be any one or all of the above mentioned symptoms with variation only in degree.

The pathologic changes resulting from exposure to or injection with beta-naphthol have not all been definitely determined. It has been

learned that after exposure to the compound, damage to the respiratory mechanism, spleen, liver and kidneys have resulted. Occasionally beta-naphthol has given rise to imperfect sight and partial retinal degeneration in man. Changes in the eye have been observed repeatedly in experiments on animals absorbing beta-naphthol. In animal experiments it is noted that the retina is dotted with bright points or to contain large yellow plaques. Further observation has shown that atrophy of the ~~optic~~ ^{optic} nerve may follow, or subretinal effusion and cataract. In this latter respect beta-naphthol resembles naphthalene, which is not surprising, since the two compounds are similar in their chemical makeup. While the ocular effects in man have not been intense, certain investigators have observed some defects of vision in workers with beta-naphthol. If only for this reason alone, caution should be exercised against prolonged contact with the compound.

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Beta Naphthol Section

Throughout published literature on toxicology, there is some dispute as to the toxicity of both naphthalene and of the naphthols. In the International Labour Office Encyclopedia of Occupation and Health, there appear extensive portions of material with regard to both of these substances. Much of the material presented is open to doubt, and the case made out against either of these substances is a rather weak one. Claims are made of serious illness and even death. It is the present investigator's opinion that at the present time naphthalene, as such, is a minor irritant to the skin, conjunctiva, and respiratory tract, and that chiefly naphthalene is a source of physical discomfort rather than serious occupational illness. In the case of beta naphthol, it is perhaps necessary to go a little farther in recognizing somewhat more dangerous possibilities. At the end of this section is presented a minor compilation ^{of} literature which is not necessarily accepted by us as representing facts, but which tends to show the type of technical material that would be used against this company in claims alleging damage. Because of this legal situation together with the discomfort situation, a few recommendations are now made.

1.) In connection with naphthalene purification, the processes are primarily enclosed although not entirely so. The various phenolic and pyridine bodies ^{removed} used provide no known practical injury. However, the stack from this operation gives rise to an almost continuous discharge or minor snowfall of naphthalene flakes. This, however, constitutes a so much more minor air contamination than many others that it is deemed expedient to ignore this situation at this time.

2.) Throughout this entire section there are many unnecessary leaks giving rise to accumulation of naphthalene crystals in unnecessary and unwanted places. For example, about the sulphonation process there are many minor leaks which give rise to visible clouds of naphthalene in the air and to settled naphthalene on all horizontal projections, piping, etc. It is recommended that greater effort be made to

eliminate naphthalene leakage connected with various processes and to maintain these operations without undue leakage.

3.) It is believed to be desirable that all workers exposed to naphthalene in the atmosphere as a continuous situation should wear light respirators of the general type provided in this plant for protection against lead dust. However, it is possible a lighter filter may be used for protection against naphthalene and beta naphthol than is necessary for protection against lead. This, however, is not important. As an example, the worker who manipulates the product sublimed naphthalene as it appears in the collecting chambers in the sulphonation area would do well to wear a respirator at all times. It has been observed that he does not wear a respirator. This same statement applies to all other operations in this section dealing with dry products, and particularly it applies to the workers about the milling and barreling process.

4.) It has been stated to be a general desire in this section to make use of safety lamps with regard to explosion. It has been observed that on that floor on which the sulphonation process is located several electric lamps are not of the safety variety.

5.) Because of the very extensive use of mineral acids and of caustic alkalis in this section, one safety shower should be provided in the event of an accident involving either of these types of substances. No such safety shower was observed although the possibility exists that such may be present. No fixed location is specified for this installation, this being left to the ingenuity of the Engineering Department, the requirement being to locate this shower in the position most accessible to workers at several points, ^{any} all of whom might be involved in an acid or alkali accident.

6.) Throughout this whole section and, in fact, throughout the whole department, there is no adequate drinking water supply. Many inverted bottle types of fountains are observed, most of which are empty and several of which are dirty. It is recommended that for this entire section, department, and plant some consideration be given to the furnish-

ing of palatable drinking water. It is recognized that this recommendation should not appear here, and it will be repeated in the general recommendations to be made. Nevertheless, this department seems to be in great need of ^{the} physiologic service.

7.) In view of the fact the materials as handled on the fusion tank balcony are substantially dust free, the wearing of respirators is not known to be necessary, but the desirability of eye protection through the wearing of goggles is obvious. It has been observed that some workers do not wear goggles, at least not at all times. Caustic burns of the eye are always serious, and multiple possibilities here are provided for such burns from minor chips, caustic splashing, hand contamination, etc.

8.) After the chipping operation, the beta naphthol is milled, and because of high temperature it is located on the floor to cool it. This entire milling operation is a dusty one, and apparently the process is uneconomical. It is known that the management proposes to aerate at this stage of the process in order to avoid ~~lower~~ ^{floor} cooling. This is highly recommended by the hygienist who further recommends that this material be mechanically conveyed to the final milling and packing operation where a great deal of dust is known to be produced at the present time, and where the bag dust collectors are shabby, makeshift affairs for a dust collecting system.

9.) This item is largely a repetition of the last statement above. It is reiterated that unnecessary quantities of dust are produced at this operation, and a better type of handling beta naphthol is desirable as well as a better type of dust arrestor.

10.) In general, this section is appraised as discomforting rather than dangerous, but many casual complaints have come to the attention of these investigators from workers in this section. Without making any claims that workers in large numbers will be disastrously affected, it is no less urged that working conditions in this section be considerably improved, chiefly on a comfort basis.

Azo Dye Section

This entire section is most distressing because of the large quantities of dust produced and the worthlessness of the dust arresting equipment now in operation which does little more than contribute to the dustiness of the workroom and because the matter of dust control has gotten well out of hand. Fortunately, the finished dye dusts are comparatively harmless, which fact in this instance is all that saves this section. With these statements as the key to this section, certain details are now presented, not all of which are connected with dust and dustiness.

1.) On the loading platform of building 505 in connection with the filling operation, some litharge is used without any regard whatever for its injurious properties. Fortunately, not much lead is utilized. Containers of dry litharge have been observed to be emptied into vats with the production of clouds of lead dust. These investigators have been somewhat nonplussed by the appearance of effects of lead absorption in the Chemical Products section. This type of minor use of lead apparently is responsible for the observation made. In view of the fact that this lead dust will hang in the atmosphere for indefinite periods, it is recommended that if this lead process takes place as frequently as two or three times weekly, the particular operator manipulating this lead be furnished a respirator. Other reasons for the wearing of respirators in this work are related to the use of other organic ingredients, such as barium, strontium, etc.

2.) At this particular portion of the section, a fair amount of mineral acids, including nitric acids, are used. Such acids are handled without any mechanical devices and often under dubious conditions. Elsewhere comment has been made upon the unsafe nature of carboy containers for acid, much wood being rotten. It is now recommended that mechanical devices be provided for the hoisting and dumping of acids on this floor level. It is recognized that much acid is used throughout

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this entire section, in various rooms, and possibly on more than one floor. Therefore, it may be difficult to handle all acids through mechanically driven emptying and hoisting devices, but at least at this one point of concentrated acid work mechanical devices should be provided. Also, workers here and elsewhere handling acids should wear goggles for protection against acid burns.

3.) As mentioned in many other places, safety showers are needed wherever mineral acids are handled. It is recommended that a safety shower be installed on this floor and in as close proximity to the point of acid manipulation as possible. While this is primarily a safety measure and not related to the hygienist, the need is so great that no hesitancy is felt in making the suggestion.

4.) On this floor level in this section, much visible water vapor is almost continuously present. Undoubtedly, this is much worse during the winter months. Due consideration should be given to the practicability of evacuating this room through window fans. This item is not regarded as outstandingly important compared with certain others in this section.

5.) On ^{this} ~~the~~ same level of building 504 (third floor) enormous quantities of dust are present, and in some places settled dust is literally present as deep as one inch. In part this dust is created in connection with the filling of milling machines on the floor below. But very particularly dust is produced and perpetuated in this general section by the bagging of the dust arrestor. This dust arrestor is located immediately in the open work room and is so heavily overloaded that it is necessary to beat it down at frequent intervals. In turn, the dust arrestor gives off prodigious quantities of dust, making travesty of the pretense of dust collection.

The same class of caustic remarks are to be made with reference to blenders, milling machines, barreling operations, and every other portion where dry materials are handled in this section. On one of the cubicle blenders, the suction is so low as not to register on the

Pitot type of air motion meter. Even if there were adequate air motion through this hood, it would accomplish nothing because the bag system for collecting dust is located in the same room only a few feet away, and it in itself is a major dust producer.

It is the general intent of this discussion to condemn most vigorously all of the dust cleaning systems in this section and to emphasize the necessity of dust collecting equipment because of the quantities of dust inhaled even though this be a comparatively harmless dust. It is known that plans have been drawn for rehabilitation of this Azo Dye Section. There is every reason to urge upon the management that these plans or some plans for modification be accepted and that alterations be made in short order.

Meta nitro para toluidine Section

6.) In this section which is predominantly one of red dye production, there is produced meta nitro para toluidine. The constituents of this dye and intermediates are traditionally known as dangerous. The finished dye apparently is little toxic but is objected to by the workers because the skin is dyed yellow and is removed only with difficulty, the urine is dyed yellow, etc. Workmen involved dislike to wear respirators because the respirator tends to increase the grinding in of the dye into the skin of the face. On this account, it is desirable that a better type of exhaust system be introduced in order, if possible, to eliminate the necessity of respirator wearing by ^{the} one man engaged in milling operation. At the present time great quantities of dust enter the small workroom, and the desirability of respirator wearing is obvious under present conditions.

It is quite probable that there may be found certain protective non-greasy pastes which may be applied to the face and hands of workmen which will break the contact between the dye and the skin. At the present time the only ^{used} ~~known~~ agent of this sort is the DuPont "Protek", but it is advised that there are a wide variety of these pastes designed for particular operations, a greater number of which are manufactured by the Mil-^{lenn}bourne Company of Detroit. This particular problem should be placed in

the hands of the Milburn Company who probably will have available some material practically applicable in this department. The remarks here written are with particular reference to mets nitro para toluidine but apply with equal significance to certain of the red dyes which also are objectionable.

7.) It seems necessary to recommend that all workmen continue to wear respirators in this section because of the high concentration of dusts even though no respirator will provide 100 percent of protection and even though a certain amount of grinding in of the dye is produced by the respirator. After all, there is no such thing as a wholly harmless dust, and large volumes of most innocent of dyes can be taken into the lungs and serve no beneficent purpose. Another section of this report deals with respirators and their care. It is believed that this Azo Dye Section should be made the recipient of special consideration with reference to types of respirators and their servicing. It will probably eventuate that workers in this section be provided with two respirators in order that alternately they may be serviced in order to escape all possible irritation. It is observed that many workers in highly dust areas do not wear respirators. It is further observed that some of those who do are remarkably stained under the respirator and that some evidence of facial skin irritation to both the areas covered by respirators and also on the neck, below the ears, etc., is present.

8.) In the filter press section of this department, a great deal of water vapor or steam is created, and wetness is everywhere present. These matters are highly characteristic of this sort of work. Of course, it may be recommended that steam be withdrawn from the room by exhaust fans in the wall, but incoming, replacing cold air would merely increase the quantity of water vapor. Thus, it is somewhat impractical to make any recommendation although in summertime much might be gained by evacuating steam and the highly humidified air.

9.) In addition to various mills, blenders, barreling operations already mentioned, there is another enormous dust maker in the air separator located on the first floor of building 503. The same sort of

dusts are here produced, and the same enormous quantities which characterize the entire dry section of the layout. This specific machine is mentioned only inculpating the entire section which truly is in need of extensive modification at the earliest possible time.

Acetanilid and Acetoluid Manufacture

In this small area which is not overly crowded, considerable tankege and storage of toxic material takes place under the supervision of the same foreman responsible for the manufacture of acetanilid and acetoluid. It is well known that considerable health risks are involved in the piping and transferring of materials like nitro benzol and acetanilid from tank cars to tanks. These dangers seem to be well known to this foreman who describes earlier periods characterized by accidents, while at the present time he feels that all have been eliminated through care in connection with leaks, vents to the roof, etc. At any rate, no evidence is at hand warranting condemnation of operations connected with these storage procedures.

However, in the manufacture of acetanilid, all is not as secure as this foreman would have us believe. He himself pointed out that in the charging of the acetanilid still it is impractical to operate the condenser so that some aniline vapors and certainly acetic acid vapors may be discharged into the workroom. This foreman himself recommends that an extension be made of the long pipe to the nearby exhaust system for the acetanilid dust. This, however, is impractical inasmuch as these vaporous materials will not lend themselves to joint evacuation with dust. Instead of this procedure, it may be well to provide a separate evacuation duct for these vapors. Provision of such will require very little expenditure of money.

It must be recognized that acetanilid is a dangerous substance and that its dust has brought about many industrial poisoning cases in plants where it is manufactured or manipulated. The arrangement and operation of a chipper machine for acetanilid gives rise to a lot of dust and spillage. The dust collecting system is entirely inadequate. Numerous

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right angles of conduits, low velocity of air movement, poor design of hood at the point of entrainment, and faulty location of the discharge point are all factors in making the system ineffective.

It is recommended that this entire area be cleaned up and freed of spilled acetanilid that may be ground under foot or otherwise eventually become dust. It is recommended that the dust collecting system be re-designed and improved, that the outside stack either be elevated in its present position or moved over to the nearby wall and elevated at least five feet above the roof of the Beta Naphthol building. This entire operation is regarded with more apprehension than is recorded by persons in charge of it.

Tobies Acid, Paraphenylene Diamine, Mono Acid, Lake Red C Amine

Best known to the medical profession of all injurious dyes is paraphenylene diamine which has caused many hundreds of cases of asthma, eczema of the face, chronic skin disease, and other affections, both as occupational diseases and otherwise. In the fur trade this substance is a notorious trouble maker where it is still used as a dye. Women wearing cheap furs dyed with this material have presented many cases of local infection and asthma. It is sold as a hair dye and is a well known cause of poisoning.

In its manufacture, its ^{main} ~~real~~ ingredient is para nitraniline, which in itself may be a source both of systemic and local disease. As long as the operations involved are wet, opportunity for damage appears to be practically nil, but dusty processes are regarded with high apprehension, and long contact with this material may lead to discoloration of the skin. In the course of the manufacture of paraphenylene diamine, the chief point of concern is in the handling of the crude dry and dusty material preceding distillation. The collecting chamber below the dryer is enclosed but not vented. The foreman claims that venting is not necessary because no workman is near this area except for a few minutes at the time of the removal of the partly filled drums. This idea is not at all subscribed to by the present investigators, and it is believed

that this entire dry operation should be vented. Also at the immediate time of removal of the filled barrels and the shaking down of the hoppers, it is believed that ^aone worker concerned should wear a respirator which also should be worn in connection with any other handling of paraphenylene diamine, particularly under dusty conditions.

At this plant, without any effort to detect same, there came to our attention at least five cases of chronic asthma and rumors of a larger number. No effort has been made to examine these patients as it has not been the policy under the guidance of the management to undertake physical examination of workers. On this account, it is not known that these patients ^{at}contribute their asthma to any substances appearing in this entire plant, or contrariwise, what particular substance or substances might be responsible. On a by and large basis, it is believed that no one substance would be responsible for all cases, nor that all cases are of occupational origin. No less, there is some suspicion that paraphenylene diamine may in at least a minor measure be responsible for certain of the asthmatic conditions encountered.

In connection with paraphenylene diamine distillation for purification processes, it is observed that the crude, fine, dusty material is dumped onto the ^{floor} ~~fire~~ near the still and is shoveled by hand into the still. This is unnecessary and highly conducive to dust formation and thus undesirable. Ways and means should be found to right this practice through the direct emptying of containers into the still by workers wearing respirators.

During the recent years and up to the present time, sulphur dioxide created by many operations in this department has been most troublesome. Wooden conduits are now installed over the vats chiefly responsible for this gas. This gas, along with other offensive vapors, is evacuated through the roof of the building. This, while bringing much improvement, has not rid the plant entirely of exposure to the gas. Many days sulphur dioxide is swept down into many buildings, possibly including homes and other factories unrelated to this company. At the present, no recommenda-

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tion is made to additional steps in the disposal of sulphur dioxide, but it is probably only a question of time until outside complaints, including perhaps legal complaints, will require additional safeguarding activities.

In connection with tobas acid manufacture and possibly other chemicals, a fair amount of ammonia is utilized but under conditions of almost entirely enclosed systems. No less, recommendation is made that at least one ammonia respirator be available immediately in the area making use of ammonia and that this be serviced and inspected by the Safety Department.

In the Lake Red C Amine Section there take place various sulphonation, chlorination, nitration and reduction processes. All these operations are vented to the outside but in one instance, believed to be the sulphonation and nitration of Lake Red C Amine, the preceding intermediate is dropped into a retort through what amounts to the actual stack for venting purposes. Since there is no induced current in this stack, the operation may become, and, in fact, is at times very dusty. This particular method of handling this step appears to be undesirable.

It is noted that throughout this section acids are piped to the point of use, thus obviating the necessity of carboys. Inquiry was made as to the length of life of piping and the statement was made that in one case nine years already had elapsed since the installation was made. To the extent that this is practical, it is ~~desirable~~ desirable that other portions of the plant using the carboys manually handled should make use of this procedure.

In this general area represented by the sulphonation process, at least one filter press gives off large quantities of visible water vapor (steam), and thus contributes to the general discomfort of this workroom. With as many stacks as there are in this general vicinity, the question is raised as to the possibilities of hooding these hot filter presses in order to discharge the steam vapors to the outside, thus in some measure protecting the workmen against this additional minor item of discomfort. Due to long years of action of chemicals, probably chiefly

sulphur dioxide and acids, large portions of this entire section are most unsightly—corroded, encrusted, worn, soggy, dilapidated. It is granted that these conditions do not directly represent health hazards, and it is equally granted that in large measure this is the result of normal operations connected with this sort of mechanical manufacture. It is, no less, urged to the extent possible that this sort of work condition be avoided and eliminated.

Fuchsine and Printing Ink Section

The basic raw materials of this division of work are well known intoxicants and chiefly are aniline, nitro benzol, formaldehyde, and mineral acids. In connection with the first handling of nitro benzol and aniline, the possibility arises that some vapors may escape because of incompletely enclosed systems. This is particularly true in proportion to the amount of heat introduced into the operation. It is recommended that these semi-closed systems be made as completely closed as is compatible with work requirements.

In connection with the recovery of aniline and nitro benzol, opportunities exist for leaks in the piping. Again it is observed that any such opportunities for contact with these substances should be eliminated.

In connection with the production of para rose aniline, much opportunity exists for contact with nitro benzol and aniline. Although the bulk of these materials are recovered in the distillation process, much free aniline and nitrobenzol inevitably must be carried over into the melt. Throughout all of the earlier purification stages of the fuchsine, some free aniline is likely to be present, thus introducing the liability of exposure. However, the nature of these operations is such that precise protection may not be afforded. In view of the apparent long experience in this department without evidence of any type of poisoning, it is felt that little justification exists for the making of elaborate recommendations. In this section, the same congestion takes place which is characteristic of the whole department. Also, protection through

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work dilution is a primary requisite. It is known that plans are already under way to extensively remodel this section. The industrial hygienists desire to lend their support to this movement rather than to urge installation of various protective devices under present conditions.

1.) Somewhat assiduously these investigators have steered clear of experimental processes on the grounds that they are in charge of highly skilled chemists and further because these experimental activities may never reach production status. However, in the case of naphthol ASBS is found a process which makes use of xylol which is blown out ^{into} of the open air ^{with} considerable quantities ^{of} beta oxy . naphthoic, meta nitraniline, phosphorus trichloride. ^{etc.} In manipulation of these several chemicals more than the usual number of dangerous materials may be involved. There have been several fortuitous episodes of distressing nature chiefly from chlorine, which has pervaded the entire building. At the present time, the condensation product is overlaid with vapors of some light body so that the chemist in charge is himself complaining of ill effects.

The propriety of carrying out large scale ^{experimental} operation in the midst of routine operations already congested is distinctly doubted. This all goes back to the basic problem of over-crowding in the absence of space where experimental problems may be set up. This leads to the general recommendation that throughout the entire plant and particularly with respect to Chemical Products and Dry Color operation, no large scale experimental operation be carried out in the midst of productive operation where workers may be exposed. And likewise the converse is made in the suggestion that suitable quarters in the present or other buildings be provided where necessary experimental work of a dangerous nature may be carried out without injury to the well-being of any workers at all and certainly those not engaged in the particular operation involved be entailed in experimental procedure.

2.) In the Printing Ink House the raw materials are handled in a wet condition, and strange to say, the chief hazard is not chemical but noise. Here again work congestion is high; all portions of the workroom are literally coated with ink materials. It is scarcely possible to

walk through the room without contamination, but after all, more attention perhaps should be paid to the ink rolls which, because of the density of materials, generally are more massive than ordinary. These mills perhaps can never be made as noiseless as the usual small paint roll mill, but at the present time much of the noise is not inherent but ~~is~~ the result of worn bearings and other parts. Ten years of continuous exposure in this building to the quantity of noise now present will eventuate in partial deafness. Again it is to be recognized that part of this suggestion is the old complaint of too many work operations crowded into space intended for perhaps one-fourth the present extent. Over and over various departments in this plant have outgrown themselves, but instead of enlarging space, the operations have been crowded into cramped quarters. Of the entire Chemical Products Department, this oft repeated complaint is the foremost one that is being made and that should be made.

3.) In the Fuchsine House where large quantities of aniline and nitro benzol are used, the method of transportation is open to question. It appears to be true that drums of these substances are obtained by filling from the major tanks near the acetanilid house, and these are conveyed chiefly by hand to the receiving tanks in the Fuchsine House. If this in fact be true as a routine process, would it not be more economic as well as safer to have pipe lines delivering these materials immediately to the point of use.

4.) In this entire section there is no single known toilet or washroom. It is necessary for any workman to come as far as building 531 which is roughly two blocks away. Throughout this whole department there is a general inadequacy of toilets although the centralized space in building 531 may be sufficient. Although the moving out of the Dry Color workers from building 531 will perhaps provide more space for the Chemical Products workers, this still will not remedy the obvious wrong in requiring workers in such remote places as the Fuchsine House to traverse two or more blocks in order to gain access to a toilet. It is very understandable that some workers who ^{may} deem it expedient use almost any

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space for urination purposes or duck into nearer toilet facilities in other departments. The workers in the Fuchsine area are mildly up in arms over this shortcoming, and at the time other sections of this department are mildly dissatisfied with facilities provided. It is therefore recommended that such comfort facilities as represented by toilets, urinals, etc., be provided at not more than one half the distance which now exists between the Fuchsine House and the toilets available. These new toilets and urinals should not be limited to the use of Fuchsine and Ink workers but should be available to other workers in this department who find this new location better suited to their convenience. It is known that the new Dry Color toilet rooms are almost across the passageway from these Fuchsine workers. It is understood that there is definite objection to multiple department use of the facilities provided for any one department. However, at this immediate time, something may be gained by permitting the Chemical Products workers to use the comfort facilities of the Dry Color Department in this area, this on a temporary basis only.

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TANK CLEANING

Unfortunate experience, in which these investigators have been involved, leads to the attachment of special concern to the matter of workmen entering any type of tank for cleaning out or repair work, provided these tanks have contained any sort of volatile or oil or other liquid material used in connection with coating manufacture. It unfortunately happens, on occasion, in spite of the best of intentions and what earlier appeared to be adequate precautions, that workers without suitable protective devices in various sorts of tanks quickly are overcome and sometimes die. Moreover, rescuers, heroic in intent, but poor in judgment, enter tanks for rescue purposes and also die. All of this is unnecessary and every large paint plant, or any plant maintaining large sized tanks should have a well thought out procedure providing safety for every type of operation involving interior tank work.

The type of asphyxiation or acute intoxication that may arise varies from substance to substance. In the case of benzol, benzol vapors themselves are responsible. Sufficient benzol vapors to produce death may be present in a tank that has been treated over a period of days by live steam, hot water, and air blowing. In the case of linseed oil, the damaging agent may be carbon dioxide, possibly with a trace of carbon monoxide, or there may be an oxygen deficiency. In the case of varnishes, vapors from the various volatiles, through their combined action, may lead to asphyxiation. The following statements may be pertinent to the situation:

1. No workmen should enter tanks unless absolutely necessary.
2. No workman should enter a tank unless previously it has been freed, as far as possible, of its contents.
3. No workman should enter a tank unless closely guarded by another workman making observation from the manhole or equivalent opening.

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Varnish Storage. The Entry of Workmen Into Storage Tanks is Always Dangerous, Calling For Special Precautions. Insofar as Possible, all Tanks Should be Equipped with Carbon Dioxide Blankets in Order to Avoid the Necessity of Frequent Clean Out Operations

4. No workman should enter a tank unless fitted with safety rope with which he may be withdrawn if asphyxiated.

5. No workman should enter a tank unless wearing a positive pressure respirator of proved suitable type. The all-service cannister type is not regarded as suitable. Breathing through a hose in the absence of positive pressure is regarded as objectionable and insufficient.

6. No workman should carry ordinary electric light into a tank and no type of light other than those approved by fire and explosion regulations.

7. In case two men enter a tank, each should be guarded by a separate individual on the outside and each should wear a separate safety line.

8. Under no circumstances should workers remain for prolonged periods in tanks. One half-hour is the maximum without emerging for a short period.

9. In most instances, a positive pressure respirator device should be of such type as to also provide eye protection.

10. Due consideration should be given to the possibility of static electricity sparking or other sources of ignition in connection with work in tanks.

TOILETS AND WASHROOMS

A casual survey was made with reference to toilets, washrooms and lockers, with chief regard for the sanitary considerations. Emphasis was placed upon facilities available, equipment, cleanliness, servicing, the use of washrooms for eating purposes, the issuance of work clothes in connection with washrooms and finally to crowding. As a result, the following comment is made:

All grades of efficiency in management and equipment are found in these units, all the way from the old, cramped quarters in the White Lead Department to the modern unit in Building 115, which is not yet occupied.

In some instances, the exposures connected with work are obviously carried over into some washrooms. In the White Lead area, this is particularly noticeable. Here considerable quantities of white and red lead are tracked in on the feet of workers and on clothing. This becomes spread over the floor and contaminates the air. Since workers do not wear their respirators, under these circumstances it is believable that this condition may be a factor in the fairly high numbers of workers believed to be suffering from lead absorption. In this area, the lunchroom adjacent to the locker room is badly crowded; due to inadequate facilities, a number of men are required to eat their lunches in the locker room, some on the floor or spread out on newspapers. Thus the very purpose of getting away from work exposures during lunch hours is defeated, due to the perpetuation of exposures in the places provided for eating purposes. Offsetting this unfavorable criticism, it is noted that in this area directions are given for washing of hands before eating, changing of clothing and general hygiene. These promulgated rules are not obeyed in their entirety, but the men in general seem to realize the danger of lead and exercise a fair amount of precautions.

This general sort of objectionable condition is also present in the Dry Color Group, in that lunches are eaten by most workers in the locker rooms of Building 55L, in the absence of tables or adequate provisions insuring freedom from lead. In this department it is noted that clean uni-

forms are provided each workman, including underwear. It is believed that the new provisions now being made in Building 115 for workers may obviate much of the difficulties here complained about.

Servicing

Each unit is serviced by some employee who is responsible for its maintenance. In some units, as in the lead unit, the caretaker also issues overalls. In Building 551, this is done by a special storekeeper. Caretakers are charged with reporting men who fail to comply with regulations governing lead workers. In the lead unit, lead dust "tracks in" in great quantity and offers quite a problem to the caretaker, requiring his continuous mopping.

"Phenoline", a disinfectant made by the Company, is used widely for disinfecting closets, floors, urinals, etc. Liquid and powdered soap dispensers are in wide use. In the paint units a bar soap is in use.

Women's Toilets

Adequate provision is made in most instances for women workers, but the three women employed in the White Lead Building, two in the office and one in the factory must cross the railroad east of the Building and go to the women's rooms in the General Office Building. On this route, they must pass through the General Offices themselves or climb over the shipping platform on the west side of the buildings.

Facilities in the Tin Can Plant are especially praiseworthy. Here a comfortable rest room is provided for women, adjoining the cafeteria.

Label steaming is done in the women's room of the Stock and Distribution Department. Apparently this is simply a matter of convenience, part of the time being done outside and part inside this room.

Women's facilities are particularly inadequate in the Factory Office Unit.

Each lunchroom has its own women's room for its employees, except the Tin Can Plant, whose workers use the common women's rest room.

Race Segregation

Colored and white have separate facilities in the Lithopone Plant only. In the lead unit, they mix freely, and this holds for other units also.

Lockers

Generally, one locker is used by one man only, but in some units lockers are shared by two men. Locks are out of order or missing on large numbers of lockers. Combination locks would avoid loss of keys, breakage and insure usability of lockers at all times.

Showers and Laboratories

Showers in the older units are not well maintained in all cases, some being out of repair. Crowding in shower rooms is acute, particularly in the lead unit, where only one doorway serves for both entrance and exit. Bad congestion at shower time occurs, aggravated by the use of too few showers. This need is met better in the Building 115 unit, where the shower rooms have two doorways.

The shower in the Varnish Department unit is situated in the open in the common washroom where drafts are uncomfortable.

Emergency showers, not for routine use, are provided in the Tobias Plant and in Acetanilid.

No toilet, washroom or shower facilities are provided in the Fuchsin Plant, their facilities being in Building 551, about a block away. No toilets are found also in the Tobias Plant.

Bradley sinks of circular design with centrifugally arranged water spray are installed in Building 115 units, which should increase efficiency greatly over the old type individual sink.

Fountains

Many fountains are simply upturned pipes. Ice is the cooling medium in summer.

Salt Dispensers

Salt dispensers are in widespread use in the Plant, but in the hot weather were seen to be little used and some poorly maintained.

Overall Washing

Overalls are washed by the men in the Lithopone Plant and hung up to dry in a warm cabinet with mechanical exhaust. Other overalls and garments are laundered apart from the plant premises.

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COMMENT AND RECOMMENDATIONS

1) The lead manufacturing departments are in need of increased service facilities of the character discussed in this section.

No recommendation is made that a new building be erected or that any particular space or area be chosen for this purpose. No less, the recommendation is made that increased facilities as to washrooms, eating space and locker rooms be provided.

2) In the same area, only three women are employed, but it is apparently true that no toilet is available nearer than the Tin Can Department or such facilities in the Main Office area. This situation is probably illegal, but regardless of legality is not commendable and should be remedied.

3) Many toilets, washrooms, etc. are maintained on a higher plane than others. This of course merely reflects difference in standards, supervision and in the interest and ability of persons immediately responsible for clean-up work. It is observed that every department or plant functions as a unit in this respect. In a later section, the general recommendation has been made that greater centralization be provided for the supervision of many types of services, including certain aspects of janitor work.

4) In the warehouse area, presumably rented from the Pullman Company, hot water is not available and particularly complaints are certain to arise in the 108th Street Warehouse where the toilet and washroom is of low order. Here, however, only one man is employed so that recommendations are not in order. However, in the 104th Street group, sixteen men are employed and there hot water should be available for clean-up purposes. The toilet at 108th Street is said to be out of order from time to time.

5) Label steaming is daily carried out by women workers in their washroom in the Shipping and Storage Department. About half of this work is carried out in the washroom and half in the general work area. This seems to be undesirable and should be discontinued.

6) At the present time, much eating of brought lunches takes place in objectionable washrooms. Elsewhere discussion is provided as to altered eating facilities for workers who bring their lunches. These changes

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should be brought about with celerity and as soon as possible no eating should be permitted in washrooms where dangerous materials such as lead are present. Conversely, every effort should be made to maintain eating places free from the contamination that now characterizes washrooms.

7) The management should be commended on the type of equipment and facilities provided in the new dry color service building. These new facilities tend to emphasize the weaknesses and shortcomings in other areas. A good type of servicing for this new building should be planned in order to keep the washrooms and toilets, etc. free from accumulations of lead and other detrimental substances.

8) One of the needs of this plant is for greater effort toward the education of workers in personal hygiene. This is discussed under a special section devoted to "Future Program".

MISCELLANEOUS ITEMS

In addition to the prime manufacturing departments, there exist a variety of ancillary divisions such as Receiving, Warehouse and Shipping, Engineering, Mechanical, Power House, General Offices, etc., none of which present any hygienic problems of the first magnitude. These items are mentioned here merely to give completeness to this report and to give evidence that their respective work activities have been considered, viewed and appraised.

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RESPIRATORS AND RESPIRATOR SERVICING

At the present time, the very heart of protection of workers against toxic materials in this plant is found in the wearing of respirators. In their absence and in the absence of faithful wearing of them, this plant in a few weeks' time would be confronted with scores of serious occupational diseases of several varieties. In any plant, the continuous wearing of respirators is more or less an admission of defeat, because in any plant the protection objective should be to so bring exposures under control that the continuous wearing of respirators will not be necessary. However, in this plant, there are certain operations, chiefly connected with lead, which will never lend themselves to so much improvement that the necessity for wearing respirators will not exist. Also, at this very time there are numerous places where extensive mechanical improvement may be made, but for the time being it will continue to be necessary to wear respirators and in fact it is roughly estimated that the wearing of respirators should be increased under present conditions by at least 25%. As improvements are made, in keeping with the general program outlined in this report, the number of men expected to wear respirators should appreciably diminish. In short, the numerical curve should extent sharply upward at the present time and then after a few weeks or months a gradual downward trend should be brought about.

It is believed that so much lead dust is present in a few places that no filter type of respirator may be regarded as entirely satisfactory. One such place is within the stacks at the time of drawing work. Here, in another portion of this report, the recommendation has been made that positive pressure respirators of very light type be introduced. If this proves to be successful, and there is no reason why it should not prove to be successful, it is possible that other points may profit by this innovation. However, at all times marked limitations exist since the radius around which a worker may wear a positive pressure respirator is obviously circumscribed.

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The type of filter respirator almost universally worn in this plant is highly regarded. It is not known that any change should be made, although the Wilson type (#400 and 401 ?) is perhaps just as efficient and possibly a little more so. The choice of the light positive pressure respirator which should do no more than cover the nose and mouth should be between those manufactured by the Mines Safety Appliance Company and the Wilson Products Corporation. No preference is expressed.

There is still in use in this plant a few old single disc respirators of a somewhat antiquated type. These should be collected and replaced by superior varieties.

Of course, the filter type of respirators, so valuable in the lessening of dust exposures, are of no worth against gas and vapors. There are a few places in the plant, such as in the Dry Color Department where intermittently workers may be exposed at times to dust and at other times to gases or vapors. It is almost impossible to expect to control this situation through the wearing of breathing appliances, such as are under discussion. Here more attention must be paid to the entrainment of these toxic materials in exhaust systems.

In the Chemical Products Division, in connection with the handling of dry materials, such as Azo Dyes, some workers present on their faces, under the respirators, almost as much skin coloring as outside the respirators. This of course means that the respirators are either inefficient or are not worn at all times, or both. In this particular section, the dust exposure is so great that means of protection other than the wearing of respirators are in order and elsewhere are presented.

In certain departments, such as Dry Color and Chemical Products, the dusty materials against which protection is sought are themselves the source of skin diseases. This is particularly true of Azo Dyes. The wearing of respirators increases the prospect of skin diseases at the point of contact between the rubber face piece and the skin. Furthermore, the action of the rubber face piece tends to grind in the dyes until they are removed through washing processes only with difficulty. Naturally, workers

object to going about their affairs apart from work with a ring of color around their faces. It is recognized that any oily materials applied to the face designed as a barrier against deposits of colored materials will tend to rot rubber of respirators and shorten their period of service without leakage. It is believed that non-greasy chemical materials that are non-injurious to rubber are available. This problem should be presented to the Milburn Company, located in Detroit, and they should be asked to devise and provide suitable protective chemicals of this character. If for any reason this company will not undertake this responsibility, other sources of such materials will be furnished. However, all of this comment tends but to emphasize the definite need for other forms of protection than from respirators.

In one section of the Paint Division, ammonia is used in small quantities in the manufacture of metal polishes. Here a light type of ammonia respirator should be furnished. This statement applies to any other departments consistently using ammonia.

In general, there appears to be a need for the furnishing of a greater number of suitable chemical respirators of varying designs for emergency purposes in other portions of the plant. It is known that various emergency devices are available in the Safety Department and that a few are located at strategic points in the plant. No less, the impression is that more equipment of this character should be available and that such should be worn to a greater extent than is now true. It is impractical to specify precise points where such additional equipment should be located. Without having determined whether a respirator of this character is located about the chlorine work connected with turpentine purification, it is stated that if a respirator is not already here provided, this constitutes a good example of the location where such special equipment might be made available. Another example may be cited in the new benzol still house. It is of course recognized that no one type of respirator may be serviceable for all of these special requirements.

Running through all this comment, the underlying thought in the mind of the writer is that elsewhere the specific recommendation is made that the company utilize the services of its own full time industrial hygienist or hygienists. Influenced by the thought that this great need actually will be filled, many statements with reference to respirators of various sorts are here curtailed because of the feeling that this is the very sort of work that may be carried out to advantage by the prospective industrial hygienist. Therefore, if this section appear to be inadequate, let it be in mind that the details of this problem at an early time should be placed in the domain of this new service addition, intended for all plants of the company.

Since the wearing of respirators is so important to the workers in this plant, much needs to be said about the testing, servicing and supervising of respirators and respirator wearing. This matter at the present time is being given extensive consideration by the Safety Department. An instruction sheet, prepared by the Safety Department, is in the course of distribution at the very time of the writing of this report. On this account, no attempt is here made to delineate the details of washing, disinfecting, inspection and servicing of respirators. In due time it is hoped that with the advent of an industrial hygienist, cooperating both with the Safety and Medical Departments, even more attention may be paid to this necessary matter of obtaining the best possible results in the protection of workers through the supervision of respirators and respirator use.

COMMENT AND RECOMMENDATIONS FOR THE MEDICAL DEPARTMENT

In another section of this report, the definite recommendation has been made that the time has come when this company should procure the services of its own industrial hygienist for coping with the problems of industrial hygiene and occupational diseases in all of the company's plants.

If this is done, this fact very definitely alters the type of recommendations that may be made in connection with the medical work in this plant. Conversely, if this recommendation is not accepted, the type of program to be carried out by the Medical Department at this plant is definitely a different one. This being true, a number of items are now specified as innovations for this plant that should be carried out by some department and preferably as part of the work of the prospective industrial hygienist. If no hygienist is employed, then many of these items will fall to the lot of the Medical Department.

a) At fairly regular intervals, such as three months, routine blood tests should be carried out, seeking evidence of lead absorption among all workers exposed to lead in this plant. Since lead is almost universally distributed at the present time, this means examinations for almost the entire employee group. However, on the assumption that many improvements will be made in keeping with the recommendations of this report, the number of such blood examinations should decrease every quarter until ultimately they may be abandoned almost entirely.

b) Routinely, at such an approximate interval as three months, determinations should be made of the content of lead in the atmosphere at a large number of work points, such as are suggested by the test points made in the present study. These analyses will require special equipment and the actual tests if not made by an industrial hygienist should be made by qualified chemists in the Chemical Division rather than by the Medical Department. No less, under these circumstances, the Medical Department should be responsible for the procurement and evaluation of these tests. As conditions improve, in conformity with the recommendations of this report, the total number of tests should lessen until ultimately only occasional tests may be required.

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c) In view of the fact that the use of benzol is on the increase in this company, and in view of the fact that there is some evidence of benzol absorption, the need exists for the determination of the urine sulfate of workers exposed to benzol vapors. This test, if not made by the industrial hygienist, may require the services of chemists, since the Medical Department as now constituted will be unable to carry out this technical procedure.

d) In keeping with the belief that a greater number of occupational diseases exists at the present time and presumably at all times than is recognized, it is strongly believed that more time should be spent in the plant among its workers, for the purposes of appraising health exposures connected with the plant's operation. This is fundamentally the work of the industrial hygienist, but if no hygienist is employed, then the Medical Department workers to a much greater extent should make contact with plant operations.

e) It will be asserted and with some justification by Dr. Hess that already his time is fully utilized in the routine care of patients, both in the Company's first aid station and in connection with home and hospital visits. Granting this to be true, another reason exists for the enlargement of the health conservation staff through the development of an industrial hygiene division.

f) A definite need prevails in this plant for the better education of superintendents, foremen and ultimate workers with respect to the exposures of their particular departments. For example, some workers believe that lead is absorbed through the skin and are rather concerned to procure skin protection; to the extent that this belief prevails, this apprehension merely represents waste of energy. It should be the duty of the prospective industrial hygienist or the Medical or Safety Department to develop some educational program for the better acquainting of large numbers of persons in this plant with the danger points connected with their work and with practical ways and means for meeting these problems.

In addition to these general enterprises, which may or may not

fall to the lot of the Medical Department, a brief series of items are now set forth which directly are connected with medical work.

1) Since this plant engages in many operations leading to the possibility of asphyxiation, it is recommended that an H and H inhalator be purchased and installed in the Medical Department. This should supplant the makeshift oxygen supplying apparatus now available which has never been used. Even though this apparatus has not been used, the time is likely to come when the dire need will arise for the use of such equipment as the H and H (Henderson and Haggard) inhalator. This apparatus may be procured through any standard equipment house or through the Mines Safety Appliance Company of Pittsburgh.

2) It is believed that in every department one or more persons should be trained and qualified to carry out the prone pressure method of artificial respiration. This is especially desirable in such departments as chemical products, dry color, lacquer and varnish manufacture. The need for this experience may arise only once in five years, but when that time does arise, the carrying out of artificial respiration by laymen may represent the difference between life and death. The time lost in seeking out the plant physician may be just that loss of time leading to the death of some worker. It is the duty of the plant physician to make sure that there is a group of workers qualified in this simple step scattered throughout the plant.

3) In the selection of new workers, obviously there are a number of causes for rejection, but in addition consideration should be given to the undesirability of employing workers with any manifest skin disease or of those types regarded as susceptible to skin diseases. This plant makes use of many hundreds of skin irritants. It is always amazing that so few cases of skin diseases do arise. To maintain this successful experience, a preference should be exercised in connection with new employees for those less likely to develop such diseases. Without any prejudice in favor of negroes or against white employees, it is noted that negroes are remarkably little susceptible to occupational skin affections.

4) The Medical Personnel, irrespective of the employment of an industrial hygienist, should become outstandingly familiar with the details of every operation in the plant. Fortunately, Dr. Hess is widely familiar with these operations, but even so an increased body of information of this character is desirable in order that every case of unobvious disease appearing in the First Aid Station may be considered in terms of possible exposures to damaging agents connected with work.

5) It is recommended that the Medical Department procure and make use of a greater quantity of published material related to occupational diseases and industrial hygiene.

6) It is observed that the First Aid Station area is used as an eating place for workers not employed in the Medical Department work. Also, watchmen and others use this department as the place for cooking beverages and for eating at night during Saturdays, Sundays and Holidays. At all times it is difficult enough to maintain a hospital or dispensary in highly sanitary conditions, such as is desirable in the prevention of infection. It is therefore suggested that this practice, while not grossly undesirable, be terminated.