

Occupational Hygiene

LEAD POISONING

Report of the Committee on Lead Poisoning, presented to the
Industrial Hygiene Section of the American
Public Health Association at the Fifty-eighth
Annual Meeting at Minneapolis, Minn.,
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The Report of the Committee on Lead Poisoning has not yet been reviewed by the Committee on Research and Standards of the American Public Health Association. It is published, however, pending such review, in response to numerous requests.

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A. STANDARDS

Diagnosis—Individual Treatment—Industrial Control

FOREWORD

The committee, in submitting the following report upon standards, has endeavored to emphasize those general principles which seem best to have met the test of practical experience. The omission of data that may be considered significant by many has been made to avoid confusion and to present the argument as briefly and clearly as possible.

The committee is mindful of the limitations and has especially tried to avoid being arbitrary by an explanation and discussion of the proposed standards. It is assumed that to be of real value these standards must be practical enough to warrant their application (directly or indirectly) by the general practitioner, the industrial physician, the safety engineer, and workmen's compensation tribunals, according to their respective fields.

The report is divided into three parts: Diagnosis, Individual Treatment, and Industrial Control. Because of the medico legal importance of the subject, attention has been given in the medical sections to procedures and instructions that may with profit be followed by the physician who is preparing lead cases for compensation purposes.

It is to be understood that this is a progress report and that the committee will consider and report at a later date upon such comments, suggestions and criticisms as may arise. At the same time it is hoped that this report may form the basis of some action by the Industrial Hygiene Section looking toward the establishment of appropriate standards for guidance in the matter of lead poisoning, subject to annual reconsideration until such a time as there is general agreement in the Section upon the subject and its component parts.

For the present, a list of the industries and trades involving exposure to lead is omitted, but the reader is referred in this connection to *U. S. Labor Bulletin No. 306*. Likewise the technic of various laboratory procedures is not considered here.

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PART I

STANDARDS OF DIAGNOSIS

General Considerations

General principles—The same principles that apply to making a diagnosis in any other disease entity apply in the diagnosis of "lead poisoning." The principles recognize the necessity of taking a complete and accurate history with symptomatology, making a careful physical examination, and, finally, making special laboratory tests, such as those of the blood and urine, and in no other disease, is more attention to be given to certain specific findings in the blood and urine than in lead poisoning.

History taking—Not only "lead poisoning" but other occupational diseases are frequently undiagnosed because in obtaining a history no adequate inquiry is made into the vocation or occupation of the patient. The committee therefore urges that this question of occupation be stressed in every history. Furthermore every history sheet, chart, or record containing a request for the nature of the patient's vocation should bold face, underscore, or otherwise call attention to this item.

In order to gauge the extent of the exposure it is recommended that the exact operation engaged in by the patient be specified. It is not enough to know that a worker was employed in a lead plant. It makes a great difference whether he worked in a smelter charging a furnace with old battery plates, or in a wet color process. Therefore, there has been devised a so-called standard form for recording and reporting the essential features of an occupational disease case, which has had some 16 years' usage in various states and is presented herewith.

The inquiry into the symptomatology becomes also an important part of the history. Because of the occasional vagueness of the symptoms, and their variability as well as their identity with the symptoms of other diseases, resort must frequently be had to methods specifically directed to lead poisoning to complete the diagnosis; *e. g.*, certain *symptoms* that are most frequent if not characteristic in toxic episodes of "lead poisoning," such as the ashen pallor, or palsy, and those *laboratory tests* which are recognized as characteristic of cases of "lead poisoning."

If one consults the voluminous literature on the subject he is immediately struck with the fact that authorities have apparently disagreed for generations as to precisely what justifies a diagnosis of lead poisoning. There appear to be those on the one hand who will not make a diagnosis of lead poisoning unless colic is present; while there are others who take the position that the presence of "stippled cells" in the blood in itself constitutes a sufficient basis for a positive diagnosis, even in the absence of all clinical manifestations of this disease. A

CERTIFICATE OF INDUSTRIAL OR OCCUPATIONAL DISEASE

(7"x8 1/2")

NAME OF PATIENT

ADDRESS: Street and No. City or Village

PERSONAL AND STATISTICAL PARTICULARS

Sex	Age	Color	Country of birth
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Single, married, widowed or divorced (write the word)

Occupation

(a) Present trade, profession or work

Particular kind of work in such trade, etc.

Date of entering present occupation

Employer's name

Address

Business (kind of goods made or work done)

(b) Previous occupations:

Name of occupation	Entered (year)	Left (year)
--------------------	----------------	-------------

Previous illnesses, if any, due to occupation:
Disease or illness

MEDICAL CERTIFICATE OF DISEASE

Diagnosis of present illness

Chief symptoms and conditions

Date first symptoms appeared

Complicating Diseases (such as alcoholism, syphilis, tuberculosis, etc.)

What in your opinion caused this affliction?

Additional facts

Date of diagnosis, 193...

(Signed), M. D.

....., 193.. (Address)

Mail to STATE DIRECTOR (COMMISSIONER)

For Instructions

Reverse Side of Form

See Other Side

INSTRUCTIONS FOR FILLING OUT CERTIFICATE

Present Occupation. Precise statement of occupation is very important so that the relative healthfulness of various pursuits may be known. It is necessary to know both general trade or profession (for example, printer) and also the particular kind of work or branch of the trade (as hand compositor or linotype operator).

Date of entering present occupation is important to determine how long the worker may have been exposed to the hazard before contracting the disease.

Employer's name, address and business are necessary to ascertain distribution of occupational diseases by industries, many trades (e. g., machinists) being common to different industries.

Previous Occupations need to be known, if possible, because present illness may be due to a former rather than present occupation. Give simply the name of each distinct

occupation which the patient may have followed, with the year he entered and the year he left.

Previous Illnesses. This refers either to previous attacks of present disease, or to any other disease, due to occupation. All that is required is the name of each such disease or illness with the year in which it occurred.

Medical Certificate. In making these reports it is necessary to consider the possible influence of factors other than occupation as causes of the disease. For this reason any complicating diseases should be noted, such, for example, as alcoholism or syphilis in connection with arteriosclerosis in cases of lead or other metal poisoning. The possible effect of other factors, such as poor hygienic conditions in the home, or other personal conditions, must be considered, and when discoverable should be noted under additional facts.

A STANDARD ACT—To Require the Reporting of Occupational Diseases

Be it enacted by the General Assembly of the State of . . . (Province of) . . . :

Report of occupational disease by physicians SECTION 1. Every physician in this state attending on or called in to visit a patient whom he believes to be suffering from poisoning from lead, phosphorus, arsenic, brass, wood alcohol, mercury or their compounds, or from anthrax or from compressed air illness and such other occupational diseases and ailments as the state department of health shall require to be reported, shall within forty-eight hours from the time of first attending such patient send to the state commissioner of health a report stating:

(a) Name, address and occupation of patient. (b) Name, address and business of employer.
(c) Nature of disease. (d) Such other information as may be reasonably required by the state department of health.

The reports herein required shall be made on, or in conformity with, the standard schedule blanks hereinafter provided for. The mailing of the report, within the time required, in a stamped envelope addressed to the office of the state commissioner of health, shall be a compliance with this section.

Blanks for report SECTION 2. The state department of health shall prepare and furnish, free of cost, to the physicians included in the preceding section, standard schedule blanks for the reports required under this act. The form and contents of such blanks shall be determined by the state department of health.

Such reports not evidence SECTION 3. Reports made under this act shall not be evidence of the facts therein stated in any action arising out of the disease therein reported.

Copy of report to be transmitted to proper official SECTION 4. It shall furthermore be the duty of the state department of health to transmit a copy of all such reports of occupational disease to the proper official having charge of factory inspection.

Penalty SECTION 5. Whoever being a physician practicing in the state of . . . , neglects or refuses to make and transmit to the state commissioner of health any report provided for in section 1 of the General Code shall be fined not to exceed one hundred dollars or imprisoned for not to exceed ninety days, or both, but no person shall be imprisoned under this section for the first offense and the prosecution shall always be as and for a first offense unless the affidavit upon which the prosecution is instituted contains the allegation that the offense is a second or repeated offense.

WRITE PLAINLY WITH INK—THIS IS A PERMANENT RECORD
N. B.—Every item of information should be carefully supplied. The exact statement of OCCUPATION is very important. Physicians should state DIAGNOSIS in plain terms. See instructions on back of certificate.

large number of intermediate positions have been taken by as many practitioners and others.

Therefore, attempts are made here so to clarify the terms and classify the signs, symptoms, and laboratory findings of this disease as to make it possible for the average practitioner to make a proper diagnosis by following the leads indicated. No less we question the efforts of some to make the diagnosis "fool-proof" by specifying for example, just what the hemoglobin content of the blood must be depressed to, or precisely how many "stippled cells" should be found in a given field, and similar details. It must be remembered that it is always extremely difficult to make the diagnosis of any disease dependent upon a system of weights and measures, no matter how carefully they have been figured out. This would be a desirable accomplishment, indeed, in view of the unfortunate lack of familiarity of the average general practitioner with lead poisoning, the fact that lead workers, in the great majority of cases, consult the general practitioner before any one else, and because his findings necessarily play a primary rôle should the case subsequently come up for compensation. Certainly it does not seem justifiable—nor indeed would it seem possible thus to arrive at any satisfactory results—to attempt to lay down arbitrary rules for the diagnosis of lead poisoning such as are never used in the diagnosis of any other disease.

STANDARDIZATION OF TERMINOLOGY

Many of the differences of opinion as to diagnosis are on analysis found to be due to differences of opinion as to the definition of the various terms used, rather than to any fundamental difference in the medical interpretation of cases. "Poisoning" appears to be a rather unfortunate term, moreover, in that it tends to convey—particularly to the lay mind—ideas of extreme distress and dramatic episodes. It is felt, therefore, that considerable progress might be made in the direction of clarifying the situation and standardizing the diagnosis, if the terms were defined.

DEFINITIONS

Lead—The element Pb (plumbum), its organic or inorganic compounds or forms, or admixtures thereof or therewith.

Lead Exposure—Any environmental condition or practice that permits of entry of lead into the body.

Portals of Entry for Lead—Refers to the respiratory tract and the digestive tract. Lead may likewise be implanted in the body through direct physical means, by hypodermic injection, or by intravascular administration. With the exception of tetraethyl lead, and related organic compounds, its absorption through the skin or through abraded or lacerated surfaces may be considered negligible.

Lead Ingestion—When lead enters the body by way of the alimentary tract.

Lead Inhalation—When lead in a dust, spray, vapor or volatile form enters the respiratory passageways through breathing effort.

Lead Absorption—When lead enters the body through any portal and is taken into the tissues.

Lead Poisoning or Lead Intoxication—When absorbed lead causes subjective symptoms with objective findings.

Incipient Lead Poisoning—When absorbed lead begins to produce clinical manifestations.

Subacute Lead Poisoning—When absorbed lead causes a train of minor or moderate clinical manifestations.

Acute Lead Poisoning—When absorbed lead causes an episode of marked clinical manifestations.

Chronic Lead Poisoning—When absorbed lead causes protracted manifestations with or without acute episodes.

Lead Complications—When absorbed lead initiates or aggravates any other disease condition.

Lead Sequela—When a pathologic condition remains as a residuum of antecedent lead poisoning.

Lead Mobilization—When absorbed lead which has been normally distributed in the body is released and redistributed and (or) excreted.

Lead Secretion—When absorbed lead is subsequently eliminated in the secretions.

Lead Excretion—When absorbed lead is subsequently eliminated in the excretions.

Lead Reabsorption—When excreted lead is again absorbed into the body fluids.

Lead Elimination—When ingested or absorbed lead is subsequently extruded or discharged from the body.

Delayed or Latent Lead Poisoning—When, during lead exposure, lead absorption occurs with or without lead poisoning, but is followed by lead poisoning after the cessation of lead exposure.

Discussion of Definitions

LEAD

For the sake of brevity it is well to use the term "lead" in a comprehensive sense covering all the various chemical and physical conditions in which the metal is used in industry, hence the definition proposed. Later, the committee proposes to draw up a list of the lead compounds that are considered the most dangerous in industry with perhaps a supplemental list of those which exhibit less dangerous effects upon the body.

LEAD EXPOSURE

For the purpose of securing some definition for procedure, it is proposed that any industrial condition wherein a worker may ingest or inhale a total of 2 mg. or more of lead per day, for 30 or more days, should be considered a condition

of lead exposure, under the definition; or, any workplace breathing atmosphere containing more than 5 mg. of lead per 10 cu. m. shall be considered *prima facie* a condition of lead exposure, provided workers are employed 8 or more hours per day for a working period of 30 or more days.

By using Duckering's figures and the record of plumbism among the employees of the given establishments, the length of exposure and the character of the plumbism that appeared among them, Legge was able to make a fairly exact statement of the quantity of lead which is to be regarded as dangerous. He concluded that 2 mg. per day is the lowest dose which, when inhaled as dust or fumes may, in the course of years, set up lead poisoning. If the working day is 8 hours—as it almost always is in British industry—this would mean about 5 mg. of lead to 10 cubic meters of air. If there is no more lead in the air than this, encephalopathies and palsies will not occur, and colics rarely.—R. R. Sayers, *et al. Experimental Studies on The Effects of Ethyl Gasoline and Its Combustion Products*. Report of the U. S. Bureau of Mines, 1927, pp. 6-7.

Teleky is of the opinion that if 1 mg., or a little more of lead is taken daily for several months, it will cause plumbism. A daily dose of 10 mg. would, in the course of a few weeks, be followed by serious symptoms.—Sir Thomas Oliver, in Kober & Hayhurst's *Industrial Health*, 1924, p. 428.

Obviously, the nature of the lead substance will often determine whether an amount as little as those above mentioned may prove hazardous.

Lead exposure may be assumed in certain industries and trade processes as now pursued, and the committee proposes to compile a list of these in a future report.

Lead exposure may be suspected when a dark deposit is found on the gums, and perhaps teeth and other oral structures, or follows the application to the parts of a weak sulphide solution, and when the discoloration disappears quite entirely by the use of a toothbrush or adequate mouth cleansing, and providing the black deposits of other substances may be ruled out. When this deposit is due to lead it may be assumed that the exposure has gone no further than such—this is in contrast to the finding of the definite lead line in the gum margins, as described below, under Lead Absorption.

Whether or not the sodium sulphide skin test for evidence of exposure to lead (in any forms by which it might get onto the skin and become enmeshed in the imbrications of the horny layer) is trustworthy and feasible, and the conditions necessary for the technic of the test, are matters which the committee would be pleased to hear more about before definitely recommending this test. It is claimed that

Lead exposure may be considered verified in the case of a given worker if, and whenever, a 5 per cent solution of a soluble sulphide, *e. g.*, NaOH, or KOH, when applied to the skin turns dark (due to the formation of lead sulphide), provided, of course, that other rarely present dark metallic sulphides are absent (bismuth, cobalt, copper, mercury and nickel). In painters and others who have been constantly exposed to lead dust or solution this test is said to be often present for several days following the last exposure and even despite ablutions in the meantime. It is suggested that the test be

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made by dipping a swab in the solution and applying it to the skin from the end of the middle finger, over the back of the hand, up the arm, and down the chest to the level of the umbilicus. If lead is contained in the imbrications of the outer layer of the skin, the moistened mark so traced will turn dark and perhaps black in the course of three to five minutes.—E. R. Hayhurst—*Am. J. M. Sc.* 147:795 (June), 1914.

Lead exposure in itself is not compensable since there is no recognized disability from this condition alone.

PORTALS OF ENTRY FOR LEAD

The *respiratory tract*, and lead in dust, spray or vapor forms are considered the chief items of danger in lead poisoning. Second only in importance is the matter of taking lead into the *mouth*, as through mouth-breathing, licking the dust-covered lips, licking lead-coated objects, straining liquids or foods through a lead-coated mustache, and transferring lead to the mouth either directly or indirectly by the fingers and hands, or upon things put into the mouth (food, eating and drinking utensils, gum, tobacco, pipes, pencils, etc.). Occasionally workers have been known to chew metallic lead, solder, and the softer alloys containing lead, as a habit.

It is possible that the tear-ducts (draining into the nose as they do from the *eyes*) may prove a more important portal of entry than is now supposed. It seems quite clear that the *skin*, with or without cuts and abrasions, is practically impervious to the entrance of lead into the body, except in the case of *tetraethyl* lead.

LEAD INGESTION

By definition, "ingestion" implies swallowing, so that lead ingestion refers to lead which has passed the throat and is in the alimentary tract. It can be seen that lead in the mouth may be either spit out or swallowed; also that much of the lead in the upper respiratory passageways will find its way into the throat, to undergo the same routing as that in the mouth, while part of that in the windpipe and larger bronchi may have a similar terminal.

Lead ingestion is usually established by the finding of lead in the feces, although it may be a content of any portion of the alimentary tract. It is quite impossible in the present state of knowledge to determine exactly the previous routing of lead found in an alimentary excretion: it may have been (1) ingested, (2) inhaled and then ingested, (3) ingested, absorbed and excreted in the feces, (4) inhaled, absorbed and excreted in the feces, or (5) combinations of these. It is doubtful whether any form of ingested lead passes through the alimentary tract without some absorption. The more insoluble compounds, such as lead sulphide or lead silicate, are known to be only slightly absorbed, but a considerable portion of the soluble forms may be absorbed.

Lead ingestion in itself is not compensable since there is no recognized disability from this condition alone.

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LEAD INHALATION

When lead is in the breathing atmosphere it is in its most dangerous form, for there follows inhalation with ingestion, and possible consequent absorption and poisoning.

Experimental evidence has shown that inhaled lead may be absorbed from the nasal mucous membrane, although undoubtedly its principal points of absorption lie in the lungs and the alimentary tract.

Conclusions: 1. Particulate matter in the form of pulverized lead carbonate is readily absorbed from the upper air passages of cats and dogs. 2. The absorption is rapid and of a magnitude far in excess of the minimal toxic dose. 3. Absorption in industry of lead salts by the upper respiratory passages would therefore seem to be a definite possibility.—Hermann L. Blumgart, *J. Indust. Hyg.*, V: 157-8 (Sept.), 1923.

It is usually assumed on experimental evidence that only a portion of the lead which is inhaled actually passes through the glottis into the lower respiratory tract:

Two of Lehmann's assistants, Saito and Gfrori, breathed in powdered white lead, inhaling through the nose and exhaling through the mouth. Saito found that he exhaled 10 per cent of the quantity inhaled, that 51 per cent was caught in the nose, and 3 per cent in the mouth, and the remaining 36 per cent he assumed had passed to the lungs. Gfrori exhaled only 2.8 per cent, and the amount calculated to have reached his lungs was 43 per cent. When they breathed through the mouth they found 15 per cent was caught in the mouth and they believed that the lead in mouth and nose was eventually swallowed with the mucus and saliva. Alice Hamilton, *Industrial Poisons in the United States*, 1925, p. 44.

Lead inhalation in itself is not compensable since there is no recognized disability from this condition alone.

LEAD ABSORPTION

When lead has once been inhaled and (or) ingested, a considerable part of it is commonly absorbed into the tissues of the body, evidently depending upon a number of factors, of which ease of solubility is a major one.

Lead absorption may be said to be analogous to the incubation stage of disease conditions that are characterized by developmental periods without symptoms. It is a condition, therefore, due to lead, with objective but without subjective manifestations. It is probably true that during this period various abnormal events are transpiring which the future may disclose, and therefore permit of an earlier diagnosis of lead poisoning than is now possible.

Among the phenomena of lead absorption are to be considered the following, the positiveness of a diagnosis being directly related to the degree in which these are found to occur:

1. *Lead Line (Burtonian Line)*—That the presence of the lead line in the gums is direct evidence of lead absorption is generally accepted—lead has been absorbed and some of it subsequently deposited in the gums. The typical lead

line is frequently very difficult to demonstrate and must be carefully differentiated from venous congestion of the gums or that due to cyanosis, to bismuth and to certain other metallic deposits. Likewise the accidental local deposition of lead sulphide on the gums (see Lead Exposure) should be guarded against by the preliminary use of a toothbrush. Such deposit is usually blacker and more diffuse than the true lead line. Absorption may, however, have taken place some time in the near past and an interpretation of the symptoms of which the individual complains must not be influenced too largely by the fact that he exhibits a lead line at the time of the examination. Unfortunately this definite and characteristic sign of lead absorption is often absent, apparently due to good mouth hygiene, absence of teeth (although it may occur in the absence of teeth), or a bad condition of the gums.

A decided aid in differentiating the venous conditions mentioned is a hand lens which will reveal the fact that the true lead line is most prominent at the gum margins and consists of discrete spots which are, in fact, the sub-lying papillae of the mucous membrane which have taken on the pigment. A careful history should determine the possibility of the presence or absence of other metallic deposits.

It is a common experience, that stomach-ache in a lead worker is only too frequently diagnosed as lead colic, without further investigation. When a lead worker with a lead line in his gums, however, comes to a physician and complains of stomach-ache, the diagnosis is almost a foregone conclusion. And yet a lead worker either with or without a lead line in his gums may have a stomach-ache for any of the reasons that any one else may.

Careful laboratory examinations both of blood and of urine are required for a proper interpretation of the significance of the lead line in any given case, as well as consideration of a history of lead exposure. Since a qualitative examination of the urine for lead is of little value, and since accurate quantitative analysis requires the use of intricate methods and considerable time in the hands of a skilled chemist, the practitioner will have to depend for the present upon a careful history of lead exposure and blood findings for the proper interpretation of the blue line in the gums.

2. Laboratory Findings—The question as to whether lead is being actively absorbed into the body in a given individual at a given time can best be determined by laboratory examination of the blood and urine. It must be remembered, however, in this connection that laboratory tests must be begun at the earliest possible moment if they are to be of the greatest value, and repeated tests may be necessary in any given case.

a. Blood—Examination of the blood is a very valuable laboratory means for the diagnosis of lead absorption, for when lead is being absorbed into the body it tends to produce some changes in the blood picture. There should be a hemoglobin determination, a red and white cell count, and preferably more than one smear

examined for *morphological changes in the cells*. All of the individual elements in the blood picture must be considered together.

Briefly, the blood picture in lead absorption has the following features, which, taken together, may be considered diagnostic:

(a) *Changes occur in the morphology of the erythrocytes such as are usually found in severe cases of anemia* (see *Stippling* below). Likewise, the blood picture often undergoes rapid and great changes. These points are extremely important in differential diagnosis.

(b) *Stippling (punctate basophilia) of the erythrocytes*. This condition is more prevalent in lead absorption than in any other blood picture of equal severity otherwise, and is therefore the most characteristic finding of this condition; yet it must be considered in conjunction with the rest of the blood picture if its true significance is to be appreciated, for stippling is by no means the whole picture of the effect of lead upon the red corpuscles. There precedes it and is invariably associated with it, a marked increase in the appearance of reticulocytes (regarded as young erythrocytes prematurely appearing in the blood stream), and polychromatophilia. At times in lead absorption, reticulocytes and polychromatophilia are more pronounced than stippling. These are of course present in practically all of the anemias, but rarely so much so as in lead absorption. There likewise may occur in lead absorption an undue amount of poikilocytosis and anisocytosis in proportion to the degree of other blood changes, while nucleated red corpuscles are not infrequent.

Stippling or basophilia of the red corpuscles, however, is shared with other conditions affecting the blood, and hence in itself is not pathognomonic of lead absorption.

The number of basophilic red cells is increased above normal numbers in the following pathologic states: Lead intoxication, benzol poisoning, arsenic poisoning, in all types of anemia in which there is regeneration, hemolytic icterus, following hemorrhage, leukemias, at times in acute infections, in neoplasms involving the bone marrow, and in polycythemia.—Carey P. McCord, *U. S. Labor Bull.* 460:32, 1928.

In fact, sensitive methods will show some basophilic material in normal blood. Stippling in lead absorption may be detected in the blood intermittently and be present in variable amounts from day to day, and yet the rest of the blood picture be quite definitely diagnostic of this condition. Undue emphasis, therefore, must not be placed upon the degree or amount of stippling in the presence of other positive findings. On the other hand, the increasing presence of stippled cells appears to be of considerable importance in following the progress of a case of lead absorption, and in prognosis as preceding acute phenomena, and may therefore be of great practical importance in the industrial control and treatment of such cases.

It is perhaps well to emphasize again the fact that the diagnosis of lead

absorption cannot properly be dependent upon the presence of an arbitrary number of stippled or other cells in the blood picture, but must be dependent upon a very careful appraisal of all of its elements.

(c) The *erythrocyte count* and *hemoglobin* are only slightly reduced in all but severe cases, whether these be acute or chronic, giving the appearance of a very low grade secondary anemia. In many cases there may be no reduction whatever—in fact, there may be a polycythemia with hemoglobin over 100 per cent, but accompanied by distinct morphologic changes in the cells. "Lead anemia" then, may be said to exist when, in lead absorption, the count is about 4,000,000 or below, and the hemoglobin decreased to some 80 per cent or below.

(d) The *color index* is, in the average case, only a little less than 1, although it becomes lower where the erythrocyte count and the hemoglobin are reduced.

(e) The total *leucocyte count* is normal (5,000—10,000), but there is a slight relative lymphocytosis at the expense of the polymorphonuclear leucocytes.

Recent evidence appears to show that white cell counts may vary 100 per cent in normal persons, and should be made with the patient in the same posture each time and after the same relative amount of exercise or rest.—Walter E. Garrey, ref. in *Sci. Monthly*, Sept., 1929, p. 287.

The presence of leucocytosis usually implies a secondary infection or some influence other than lead absorption, with which, of course, the latter may co-exist. A leucopenia is not a finding of lead absorption. It may be a very temporary normal condition, but usually indicates some other intoxication, such as benzol poisoning or one of the more virulent infections producing severe degrees of anemia, but usually with temperature (*Streptococcus hemolyticus*, *Bacillus pyocyaneus*, etc.).

(f) The *mononuclear cell count* may be found to be somewhat increased—a relative increase in large lymphocytes pointing to a more severe intoxication, and of small lymphocytes, to a more sub-acute or chronic intoxication.

(g) *Other laboratory blood findings*, such as the reaction of the cells to hypertonic salt solution (Liebermann's Test), or the hermatoporphyrin test in the blood, fragility of the red cells, clotting time, and the attempts to detect lead in the blood plasma (see *Other Evidence of Lead Absorption*, below), etc., are all of value in that they give still further evidence that the blood cells are being adversely affected by lead; but these findings, except the test for lead (in expert hands), are not pathognomonic, nor are they necessary to a diagnosis.

b. *Urine*—Several laboratory workers have reported lead to be excreted in the urine of normal persons, under the usual conditions of civilization, and in

amounts commonly falling between 0.04 and 0.08 mg. in the 24-hour specimen. The term "normal lead" may be applied to this excretion for the present.

When, however, lead is being actively absorbed by the body it will usually be found to be excreted in the urine in amounts exceeding 0.1 mg. although varying in quantity day by day. Since it appears in these very small amounts, it requires the use of delicate tests to detect its presence. There are now several methods in use which are sufficiently sensitive for this quantitative determination. Such tests can be made only in laboratories equipped for the purpose. Qualitative determination of lead in the urine would appear to have little value.

At present, an *absolute diagnosis* of lead absorption at least requires the finding of lead in the urine in abnormal amounts.

Hematoporphyrin (iron-free hematin) may occur in increased amounts in the urine of more marked cases of lead absorption, but occurs also in many other conditions. It may impart a dark color to the urine.

c. *Feces*—Lead is found in small amounts in the feces of most normal persons, and more constantly and in larger amounts than in the urine, as a rule. During lead absorption, likewise, much more lead will usually be found in the feces than in the urine, but these findings are occasionally reversed for a day or so at a time. Ingested lead (*i. e.*, that which has not been absorbed) makes up some portion of that found in the feces, and there is at present no practical method extant for differentiating ingested lead from excreted lead in the feces. Hence, even the quantitative estimation of lead in the feces is of only relative value in diagnosing between these two conditions.

However, the quantity of lead in the feces is often a clue to the intensity of lead exposure if samples are obtained within some 48 hours of the cessation of exposure.

d. *Other Laboratory Findings*—The presence of lead in the nose, mouth or gastric secretions, cannot, at present, be regarded as of any significance from the standpoint of clinical diagnosis, because such is merely indicative of the fact that lead has been inhaled, mouthed or ingested, as the case may be. It is no indication that it has been actively absorbed through the nasal or gastrointestinal mucosa and so no indication that it has at any time become part of the body economy.

The possible value of the X-ray in diagnosing lead absorption or related conditions is now awaiting report.

3. *Other Evidences of Lead Absorption*—Tests for lead in the tissues of the living subject are not feasible at present except in the case of the blood where sensitive methods of analysis often show the presence of lead in cases of active absorption.

Post-mortem analyses yield information as to the quantity and distribution of lead in the tissues and, when properly evaluated, are of considerable diagnostic value. Here, again, it must be pointed out that mere qualitative tests are of little value, for small quantities of lead are commonly found in human tissues (bones

and liver especially) without any apparent relationship to the illness and death of the subject.

Lead absorption in itself is not compensable since there is apparently no disability in this condition alone. The future, however, may change this opinion should it be shown that lead absorption does result in impairment.

LEAD POISONING OR LEAD INTOXICATION

Used in the sense of the definitions proposed, all cases of lead poisoning are special conditions of Lead Absorption which present evidences of intoxication. The term "lead absorption" has unfortunately been used rather loosely in the past by some, to refer to cases which they vaguely regarded as "mild" cases of lead poisoning. There has been very proper objection to its use in this way.

Lead absorption used in the sense proposed would, by definition, not readily lend itself to varying interpretations; indeed, it is an expressive term because it definitely refers to a physiologic and etiologic process and not to any symptomatic manifestations.

Surprisingly variable amounts of evidences of lead absorption may accompany definite evidences of lead poisoning. In short, susceptibility to actual poisoning varies enormously with different individuals, and even at times with the same individual. Thus, individuals may be found with rather marked evidences of lead absorption, but without complaints or any of the objective findings of lead poisoning, while other individuals may be found with limited evidences of lead absorption, but with rather pronounced evidence of lead poisoning. Perhaps one explanation of the occurrence of acute symptoms without concomitant signs of marked absorption is the possibility of the sudden disappearance of the major portion of lead from the blood stream by its absorption into the liver, or storage in the bones. In such instances, however, the symptoms should rapidly subside.

Diagnosis—The diagnosis of lead poisoning is made upon: (1) The case history, (2) the symptoms, (3) the physical signs, and (4) the laboratory findings.

1. *The Case History*—This refers to events which have transpired in the patient's past working life and those involved in the present circumstances. The items to be considered in the case history of a possible case of lead poisoning are as follows:

A definite history of lead exposure

Direct inquiry into the trade process, showing lead exposure (This may be omitted where the trade process, such as painting, enameling, etc., is already accepted as an exposure to lead. As before stated, the committee plans to draw up a list of such industrial exposures.)

A physician's diagnosis of lead poisoning in the past

A dispensary, clinic or hospital diagnosis of lead poisoning in the past

The nature of abdominal operations performed (ulcer, gall stones, other biliary tract affections, appendicitis), and whether or not such operations relieved the symptoms, and especially whether symptoms returned upon return to the same employment

Past illnesses, keeping in mind clinical manifestations which might have been due to lead poisoning

Detention for mental up-sets, delirium or acute mania

Number of children (strong experimental and some clinical evidence of limitation of offspring)

In women, history of miscarriages and early death of offspring

2. *The Symptoms*—Since lead, which has been absorbed into the systemic circulation, bathes all of the tissues of the body, its toxic effects may be very widespread indeed. Its symptoms are therefore very numerous, depending upon the organs involved, and may resemble those resulting from other diseases of these same organs. Occasionally, a worker who is obviously "lead" denies symptoms for one reason or another. The differential diagnosis on the basis of symptoms alone, therefore, may be very difficult, especially in sub-acute or incipient cases. Indeed, there is no symptomatic manifestation of lead poisoning which is in itself pathognomonic of this condition, although the so-called "lead triad" of abdominal colic, obstinate constipation and severe headache (without fever) is very suggestive. For convenience, the symptoms to be looked for in lead poisoning are grouped systemically:

A. GASTROINTESTINAL

Loss of appetite, especially for breakfast

Coated tongue

Sweetish or metallic taste in the mouth

Nausea

Vomiting

General gastric discomfort (dyspepsia)

Colic—perhaps very severe, difficultly relieved by opiates, board-like hardening of the abdominal muscles which are apt to be depressed (scaphoid abdomen), and generally relieved by pressure (in contradistinction to most of the other acute abdominal conditions)

Constipation, which may be very obstinate.

B. NEURO-MUSCULAR

Headache—frontal, often very severe

Weakness—of the hand grips, wrist extension, general weakness, falls

Dizziness

Nervous tremor of the hands, tongue, eyelids, etc.

Backache

"Rheumatism"

Wakefulness or disturbed sleep and nightmare

Mental depression

Nervous excitement

"Neurasthenia"

Wrist drop or lead palsy—bilateral, and specially if with escape of the *supinator longus* muscle, by which the patient is unable to lift an object with his hands, but is quite capable of raising an object placed across his forearms

Ocular disturbances (diplopia)—due to optic neuritis, etc. Blind spells

Mental symptoms, such as delirium, hallucination, loss of memory, stupor, etc. (lead encephalopathy)

Aural disturbances—deafness, tinnitus
Loss of weight

C. CARDIO-VASCULAR

Fainting
Nose bleed
Palpitation

D. RESPIRATORY

Chronic bronchitis
Asthmatic attacks

E. REPRODUCTIVE ORGANS

Menstrual disturbances (See History above)

3. *Physical Signs*—There is likewise no physical sign, as this term is used in medicine, which is pathognomonic of lead poisoning. The ashen pallor, or double wrist drop, or the writhing colic is however very suggestive. Occasionally a worker with physical signs of lead poisoning denies all symptoms thereof. Here, history and laboratory findings must be depended upon.

*Pallor—"ashen pallor" which is often marked around the mouth and nose (circumoral).

The ashen pallor in lead poisoning deserves special mention in that it differs very markedly from the greenish pallor of secondary anemia and the lemon yellow pallor of pernicious anemia. It differs not merely in appearance, but in the curious fact that it appears to have no definite relation to the reduction either in hemoglobin or in the red cell count. This relationship is rather striking in the other anemias. In lead poisoning a marked pallor of the face and lips has been regarded as characteristic of the disease, but authorities agree that it may be marked in very mild cases. Koelsch believes that it is probably due to the action of lead on the skin capillaries—a vaso-constriction due to faulty mechanism. Profound anemia may, however, follow a lengthened period to the influence of lead.

*Lead line in the gums (See Lead Absorption.)

Foul Breath

*Wrist drop

Tremor (tongue, lips, chin, hands) (See Symptoms, above.)

Incoördination (fingers, arms)

Grip strength weak (dynamometer or spring-balance test), bilateral

*Strength of wrist extension weak (dynamometer or spring-balance test), bilateral

Reflexes usually decreased (knee jerks, wrist, elbow, cremasteric)

Ataxia

Ocular palsies

Deafness

Anxious facial expression

State of nutrition (some cases show a wasting of hands, arms, and perhaps general emaciation)

Acne, dermatitis

Abnormal blood pressure, but subject to wide variations:

Hypotension in early stages

Hypertension in longer standing cases

Arteriosclerosis (radial, brachial, temporal)

Signs of nephritis—chronic interstitial; nocturnal urination, edema of ankles, hands and face (small granular kidney)

Gouty signs (great toe joints, palms, fingers, other joints)

Premature aging

Evidence of mental disturbances:

Hysteria—especially in young women

Neurasthenia

Unconsciousness, coma, convulsions leading perhaps to death

Delirium or acute mania ending perhaps in death

Blindness

Brain tumor complex

Pseudo-general paralysis

Dementia with tendency to end in the asylum

The commonplaceness of the *clinical picture* (symptoms and physical signs) as above described for purposes of diagnosis is self-evident. Aside from acute colic, lead palsy, encephalopathy, or other quite obvious manifestations of "lead poisoning" (as that term is used in the present discussion) any or all of the other signs and symptoms may be due to any of a number of conditions and cannot be regarded *per se* as diagnostic of lead poisoning. A significant history with prominence of the above list of symptoms and signs may, however, be considered good *presumptive evidence* of lead poisoning. Particularly is this true where a lead line is associated.

4. Laboratory Findings—(See also under Lead Absorption.)

Blood

Urine

Feces

Skin test (sodium sulphide 5 per cent)

Other tests

An *Absolute Diagnosis of Lead Poisoning*—This cannot be made without positively finding a pathological amount of lead in the urine (or blood, tissues, secretions) accompanied by a proven history of exposure, usually, if industrial, of some days' time or more; a syndrome of several or more of the symptoms listed above; and one or more of the starred (*) items under Physical Signs listed above. The diagnosis of lead poisoning is, however, seldom *absolute* at the present time, but is made upon *strong presumptive evidence* in which the chief item missing from the above picture is the failure to examine the urine for pathological amounts of lead.

DISCUSSION

Cases for diagnosis appear to fall naturally into three classes: (1) Those with *positive disability*, (2) those with *doubtful disability*, and (3) those *without disability*.

1. Cases with Positive Disability

Procedure—The suggested procedure is as follows:

(1) It must be established that the worker was exposed to lead to a degree generally considered to be significant, because there are all manner of apparently insignificant exposures to lead which experience has taught may be disregarded, except the assumption that the individual has proved to be unusually susceptible.

(2) It must be definitely established that some of the symptoms evidencing themselves in his disability are such as are commonly associated with lead poisoning.

(3) The presence of other diseases or accidents causing similar disability must be carefully weighed as provocative of all the symptoms and objective findings present, or as causal of only part or certain ones of them, if any.

(4) The physical examination must in every instance be thorough, and the objective findings for lead carefully searched for and labelled as either positive or negative.

(5) Several appropriate laboratory examinations of the blood must be made, having in mind lead poisoning.

(6) Two or more examinations of 24-hour collections of urine should be made for the presence and quantity of lead. The usual routine urine examinations for other findings must be made. (The committee is debating the matter of attempting to state the amount of lead in normal urine. See p. 12, *Urine*.)

(7) The importance of making these laboratory tests at the earliest possible date following the onset of symptoms is reemphasized.

Diagnostic Possibilities—

(1) If the disability is such as to be definitely associated with lead poisoning, and this is further confirmed by the laboratory, there can be no doubt as to the diagnosis—it is lead poisoning. The sole point left is to establish *industrial* lead exposure.

(2) If the disability is such that its relation to lead poisoning is in doubt, the presence of laboratory evidences of lead absorption should, generally speaking, be strong presumptive evidence in favor of lead as a cause for the disability—other possibilities, of course, being weighed in the usual manner. Again *industrial* lead exposure must be shown.

(3) Cases of disability which are presented without laboratory findings of lead absorption are problematical at the best, and only strong evidence of lead exposure with symptoms and signs pointing to lead poisoning may be expected to receive a favorable hearing in a plea for compensation.

(4) Lead poisoning may exist due to lead exposure unassociated with the present employment: (a) Exposure in another employment; (b) use

of lead-containing cosmetics or hair dyes; (c) use of lead-containing medicines as therapeutic measures; (d) use of leaded foods; and (e) other accidental or intentional ingestion or inhalation of lead.

2. Cases with Doubtful Disability

Discussion—In this group are included all cases where the existence of disability *cannot* be established beyond a doubt by noting the physical signs, since the claim for disability is made upon the basis of subjective symptoms only. For example, the worker may complain of such symptoms as headache, dizziness, dyspepsia, general lassitude, etc., and maintain that as a result he is unable to work. Are these symptoms, if they exist, due to lead poisoning? Is the worker pretending or are the symptoms due to causes other than lead poisoning? It is obviously impossible to prove or disprove the existence of most subjective symptoms. Much must depend therefore upon the impression of the physician with reference to the reliability of the patient's statement.

Procedure—Every effort must again be made to determine the existence or absence of lead exposure, while the physical signs and laboratory findings require the closest attention.

Diagnostic Possibilities—

(1) If the symptoms of which the worker complains, though ever so vague, are those definitely associated with lead poisoning, and the laboratory findings show lead absorption, the presumption is in favor of lead as a cause for the symptoms and such disability as is present. All other possible causes for the symptoms and disability must of course be taken into consideration as indicated above.

(2) If the symptom complex, though vague, is doubtfully one associated with lead poisoning, but the laboratory findings show lead absorption, the presumption of evidence is still in favor of lead as the cause of the symptoms and the disability.

(3) If the clinical picture is doubtful and the laboratory findings for lead absorption are negative, the presumption of evidence is definitely against the possibility of lead poisoning.

3. Cases without Disability

Discussion—A group of cases occurs among exposed or possibly exposed lead workers where no disability or impairment is claimed. This may be due to the fact that the worker has not sensed disability or impairment, or to the fact that he wishes to conceal the same for one reason or another.

Procedure—Here every effort should be made to determine whether or not there is a (hidden) disability or impairment which could be associated with lead poisoning, for the object of preventing lead poisoning (in any of its stages or phases).

Diagnostic Possibilities—

(1) Positive blood and urinary findings of lead absorption in cases in which no disability can be discovered would simply establish lead absorption and not lead poisoning.

All Cases of Lead Poisoning in Any of its Stages Should Be Compensated. This compensation should be in proportion to the disability present, and cover the entire period or periods of disability due to or consequent upon lead poisoning.

INCIPIENT LEAD POISONING

By definition, those symptoms which begin to appear when Absorbed Lead increases beyond the threshold of physiological adjustment and evidences of intoxication appear, are called as a group "incipient lead poisoning." The symptoms are variable in this stage, but usually consist of some of the following:

1. *Symptoms*

- A. Loss of appetite
 - Coated tongue
 - Sweetish or metallic taste
 - Nausea
 - Dyspepsia
 - Constipation
- B. Mental Depression
 - "Neurasthenia"
 - Headache
 - General weakness
 - Slight dizziness
 - Poor sleep
- C. Palpitation
- D. Bronchitis
- E. Menstrual disturbances

2. *Physical Signs*

- Pallor
- Lead line
- Slight tremor
- Blood pressure—hypotention

3. *Laboratory Findings* (For details see Lead Absorption.)

- Blood positive
- Urine positive (*i. e.* pathological amounts of lead)
- Feces positive (for increased quantities)
- Skin test positive (if there has been recent skin exposure)

SUBACUTE LEAD POISONING

By definition, this condition exists when Absorbed Lead causes a train of minor or moderate clinical manifestations. In addition to the evidences cited under Incipient Lead Poisoning, which may be all more marked, one would expect to find some or most of the following:

1. Symptoms

- A. Vomiting
Colic
- B. Weakness of the wrists
Nervous tremor
Backache
"Rheumatism"
Nervous excitement
Loss of weight
- C. Fainting
- D. Asthmatic attacks

2. Physical Findings

- Tremor
- Incoördination
- Strength of wrist extension weak
- Reflexes decreased
- Acne, dermatitis

3. Laboratory Findings (See Incipient Lead Poisoning.)

ACUTE LEAD POISONING

By definition, this condition exists when Absorbed Lead causes an episode of marked clinical manifestations. Hence, to the findings of Subacute Lead Poisoning (many more pronounced) there may be expected to occur some or more of the following:

1. Symptoms

- A. Obstipation
- B. Wrist drop
Ocular disturbances
Mental disturbances (perhaps mania)
Aural disturbances
Loss of weight?
- C. Nose bleed?
- D. Bronchitis?

2. Physical Findings

- Wrist drop
- Ataxia
- Ocular palsies
- Deafness
- Anxious facial expression
- State of nutrition decreased?
- Blood pressure—hypertension
- Signs of nephritis?

3. Laboratory Findings (See Incipient Lead Poisoning.)

CHRONIC LEAD POISONING

By definition, this condition exists when Absorbed Lead causes protracted manifestations with or without acute episodes. Therefore, any or all of the

symptoms delineated under Acute Lead Poisoning may exist with an acceptance of those marked questionable under that heading, and, in addition the following:

1. *Symptoms*

- A. Obstipation with occasional attacks of diarrhea
- B. Arthritis
- C. Chronic bronchitis

2. *Physical Findings*

- A. Gums and teeth likely to be in very poor condition rendering a lead line undeterminable
 - Blood pressure—usually hypertension
 - Arteriosclerosis
 - Interstitial nephritis
 - Gouty signs
 - Arthritic signs
 - Premature aging
 - Atrophy
 - Cachexia

3. *Laboratory Findings* (See Incipient Lead Poisoning.)

Chronic lead poisoning may exist for years with only occasional exacerbations, of varying severity.

TETRAETHYL LEAD POISONING

Since the order of appearance and the character of some of the symptoms of tetraethyl lead poisoning are different from lead poisoning due to other known causes, attention is called to special literature upon the subject. (R. R. Sayers, *et al.*, *Experimental Studies on the Effects of Ethyl Gasoline*, U. S. Bureau of Mines, 447 pp., 1927.)

LEAD COMPLICATIONS

By definition, complications may be said to exist when the presence of lead in the body initiates or aggravates any other disease condition. The commonest complications of lead poisoning are those of the gastrointestinal tract, such as gastric ulcer, duodenal ulcer, gall tract afflictions, appendicitis and occasionally parotitis and orchitis.

Lead workers are at least as subject as other individuals to common ailments such as dyspepsia, stomach-ache, gastric ulcer, appendicitis, etc. It is quite obvious therefore, that all other causes be estimated in considering the health of a lead worker quite as much as in making a differential diagnosis in any individual.

Compensation for Lead Complications—Compensation should be allowed in full whenever the complication has been caused or started by lead poisoning. In those circumstances where lead poisoning has aggravated another disease condition, a basis for compensation should be reached covering the probable added damage due to lead poisoning.

LEAD SEQUELAE

By definition, lead sequelae are pathologic conditions remaining as a residuum of antecedent lead poisoning. Aside from the various changes which result in paralysis and mental disturbances of one form or another, arteriosclerosis, hypertension, and nephritis are the sequelae of lead poisoning which are most often reported by experts in lead poisoning and which come to the attention of the compensation courts. While there has been and still is some doubt as to the exact relation of lead poisoning to these cardiovascular conditions, such relationship has not been definitely disproved, and it would seem best to continue to consider these conditions as probable sequelae of lead poisoning where other obvious cause cannot be established.

Lead Sequelae Should be Compensated—provided provision is made for the same in the compensation statutes or regulations, and for the reason above stated.

LATENT OR DELAYED LEAD POISONING

Cases of lead poisoning are reported to occur in persons who have not been recently subjected to lead exposure. Such cases are defined as "latent or delayed lead poisoning." There is a deposition on the part of the committee to limit the term "latent lead poisoning" to those cases arising within a short time after the cessation of exposure, for example, within a few months, and to use the term "delayed lead poisoning" for those cases arising more remotely after the cessation of exposure (see discussion under Part II, B. "Deleading").

When a worker who is suffering from lead poisoning has been subjected to lead exposure in one or more occupations previous to the one in which he was last engaged, and in which he was also subjected to lead exposure, the committee feels that the occurrence of lead poisoning should probably be charged wholly to the place of last exposure provided twelve or more days of lead exposure have been suffered in the place of last employment.

The question of *Super-added Lead Poisoning*, i. e., a circumstance where a worker has been subjected to lead exposure in two or more consecutive or concurrent employments, is considered entirely possible. In such cases it would appear that a compromise finding might be reached by which responsibility for lead poisoning could be charged to the respective exposures in a fair and equitable manner and compensations adjusted accordingly.

NOTIFICATION

Every case of lead poisoning should be notified to the proper official agency, usually the department of health and (or) the department of labor (or equivalent bodies). To avoid duplicating statistics, the committee recommends that but one notification of lead poisoning for the same case be so entered within the space of a twelve months' interval, and that renotifications within this period of time be entered as relapses, or delayed, or latent lead poisoning.

PART II

STANDARDS OF TREATMENT

The treatment referred to hereunder is *curative* treatment. The discussion of preventive treatment properly falls under "Industrial Control." It is felt, however, that a word might here be said regarding the so-called *preventive* treatment such as the taking daily of milk, lime water, sulphuric acid-in-lemonade, magnesium sulphate, calcium sulphite, etc., which is frequently advised for workers exposed to the dangers of lead absorption. Controversy has arisen concerning the advisability of such measures and the committee has decided to defer recommending them until it has opportunity to make further investigations of the matter.

Curative treatment may be considered under the heads: (A) That directed to the abatement of symptoms of lead poisoning, and (B) that toward the removal, if possible, of lead accumulated in the subject's tissues, *i. e.*, to promote lead mobilization, excretion, and elimination. Without this latter treatment the cure cannot be considered complete. It should not be forgotten by those called on to deal with the problem of lead poisoning that certain individuals, although leaded, do not show immediate toxic manifestations but may be poisoned, with the result that they may develop degenerative changes in the arteries, heart, kidneys, liver, etc., and perhaps become prematurely aged.

A. The Treatment of Immediate Toxic Manifestations

This should aim at the abatement of "acute symptoms" for the immediate relief of the patient.

It can be accomplished by bringing about immediate cessation of lead exposure, and emptying the alimentary tract of its unabsorbed lead by means of saline cathartics. In many cases this is all that is necessary to give relief. Alternating rest and moderate activity, and a full diet usually correct the symptoms in a few days. Alkaline salts including calcium carbonate or lactate, given to the point of a maintained neutrality, are beneficial.

In severe *colic*, or for the *headache* of encephalopathy, small doses intravenously of calcium chloride, or Fischer's Solution (given very slowly) usually relieve the pain, also other acute symptoms such as vomiting. For the purpose of administering CaCl_2 , 15 c.c. of a 5 per cent solution is recommended. In practice 5-10 c.c. will usually be found quite sufficient, but 2-5 c.c. of a 10 per cent solution may be used. Hot applications to the abdomen may help to relieve the colic.

Anti-spasmodics have been advised. They may be used in cases which are

not relieved promptly by the administration of calcium. Experience would seem to indicate that these are very few.

If the patient is suffering severely and no calcium chloride is immediately available for intravenous injection, as indicated above, 1/100 gr. of atropine, repeated if necessary, or 15 drops of F. E. Belladonna in repeated doses, may be used for this purpose.

Amyl nitrite or nitroglycerine have been suggested as alternatives for this purpose. More experience with their employment is wanted before the committee can definitely recommend them.

The use of opiates, or morphine (gr. 1/8 to gr. 1/4) should be limited and restricted to the relief of unbearable pain or unmanageability, and given preferably with atropine (gr. 1/150 to 1/120).

Enemas have been found useful in stopping the pain of an attack. They may be difficult to administer because of spasm. They should be slightly warm.

Magnesium sulphate (Epsom salts) 1 oz. should be administered per mouth to clean out the intestinal tract. Castor oil may be given in severe cases of constipation. Where it is found necessary to continue the use of aperients one of the milder salines should be employed. Sir Thomas Oliver states that the abdominal pain can be relieved by the administration of sodium mono-sulphite in 1/2- or 1-gr. doses thrice daily, and states that Dr. Stevens of Cardiff has found the internal administration of 1/4-gr. dose of calcium permanganate helpful. Likewise, for colic and constipation, he recommends a mixture of potassium iodide and magnesium sulphate to which 5 drops of tincture of nux vomica with a carminative may be added. He cautions against the use of potassium iodide in repeated doses in lead poisoning. In severe cases of constipation accompanying colic, 1 drop of croton oil on a piece of sugar may be added, by mouth.

Immediately following the abatement of severe symptoms the patient should be put on a *diet* rich in calcium. This should consist of: juicy fruits, green vegetables, carrots, turnips etc; milk, foods cooked with milk, and milk products such as cheese, butter and ice cream; molasses; eggs.

A quart of milk should be taken daily. With this should be given 2 gm. of calcium lactate a day in four or more doses. If no milk is used, the calcium lactate should be increased. Calcium chloride may be used, but it is unpleasant and should not be taken by mouth in large quantities. One dr. of a 1:8 solution by mouth may be tried three times a day.

This treatment should be considered the preliminary to "deleading" and should be continued for a week in ordinary cases or until the patient is in good physical condition. In those showing nervous manifestations it should be continued until the signs are stationary. Sometimes it may have to be protracted, running into months. When *nephritis* is present, treatment with calcium and high calcium diet should be prescribed and other efforts made to clear up the nephritis before "deleading."

During *epileptiform seizures* the bowel should be washed out with mustard and warm water (a tablespoonful of mustard to a pint of water), and afterward a small enema containing 30 or 40 gr. of bromide should be administered per rectum (Oliver).

Wrist drop cases should be put up in hyperextension splints.

Cases of *paralysis* which are slowly recovering should be given passive massage and electricity.

B. "Deleading" Following Treatment for Relief of Symptoms

After acute manifestations have been cleared up or are stationary, and when the patient is in at least fair general condition, efforts may be made to remove stored lead from the body. Experimental evidence has shown that only a portion of this stored lead can be eliminated in this procedure, but presumably it is that which is the more readily mobilized and, judging by the improvement shown by a number of long-standing cases, after this had been carried out the results appeared, to be of value. The committee feels that more experiences should be reported, however, before it can recommend "deleading," but the following may be tried as an empirical measure, based upon the reports of Aub and his coworkers (in *Lead Poisoning*, Med. Monographs Vol. VII, Williams & Wilkins Co., Baltimore, 1926).

During the "deleading process" the patient is placed on a diet poor in calcium and the acid-base equilibrium of the body is altered by the administration of suitable drugs. In this way, the calcium reserve is experimentally found to be drawn upon and, with the removal of calcium from the bones and elsewhere, lead is also freed to the circulation and the excretion promoted.

It is of value to check the excretion of lead during this process by lead determinations in the urine.

The diet should not include milk or foods cooked with milk. Likewise, calcium-rich foods such as green vegetables, fruits, ordinary vegetables, cheese, butter, molasses, eggs, etc., should be prohibited.

The diet should be made up from the following: meat, liver, potatoes; rice, tomatoes and canned corn (without milk); corn meal, bread (cooked and used without milk), soda biscuits; bananas, apples (peeled); tea or coffee without milk or cream, but with sugar; butter fat (prepared by melting butter in hot water and skimming off the butter fat); salt and pepper.

During the administration of this diet the patient may be given either: (A) 15 minims of the dilute phosphoric acid (U. S. P.) every hour for about ten times daily for several weeks. (Each dose should be followed by a mouth wash of sodium bicarbonate.) It is quite distasteful to many. Or, (B) ammonium chloride, 1 gm. in a glass of water, ten or twelve times a day—some prefer the tablet form, but in either case nausea and stomach disturbances may follow.

Nephritic cases should not be given either of these drugs since they are

acidic in action. In such cases, sodium bicarbonate 20-40 gm. a day may be given to upset the acid-base equilibrium, and may be found effective in favoring the excretion of lead.

Potassium iodide, if used, should be limited to small amounts. It appears to have no advantages over ammonium chloride or phosphoric acid and many disadvantages. One of these disadvantages is that it is not so effective. Likewise, this drug is contraindicated in nephritis.

During this treatment the patient should be in bed, preferably in an institution or where he can be very closely watched throughout the course. The first signs of the return of toxic manifestations should be treated by increasing his calcium and curtailing the deleading treatment until symptoms abate.

When acid "deleading" is being applied, symptoms of *acidosis* such as loss of appetite, headache, malaise, dyspepsia, bronchitis, and rheumatic pains, should be indication for reducing the dosage. During alkaline administration, symptoms of *alkalosis*, i. e., hypersensitivity to tetany, should be treated in a similar way—dosage should be restricted and, where necessary, calcium administered.

It has been found advisable to carry out "deleading" in the form of courses. Intensive treatment is applied for five or six days and then discontinued for a week or ten days during which time the patient is permitted to partake of a more liberal diet. This break is followed by another course of intensive treatment, and so on.

As previously stated, it is advisable to check the course of "deleading" by laboratory estimations. By this means the number of courses required to render the patient "delead" can be better defined. It must be remembered that the term "delead" is only relative, since only a portion of the stored lead may be eliminated in this way.

Where it is not possible to follow the course of "deleading" by laboratory examinations, two courses of five or six days each, with a break, are recommended for ordinary cases. Those with signs of nerve damage should preferably be brought back for a second double course within a period of six months.

When the deleading process is complete the patient's calcium balance should be restored and he should be able to return to work at the end of a week or ten days. He should be advised not to undertake work which exposes him further to lead.

PART III

STANDARDS OF INDUSTRIAL CONTROL

A. *The Problem*

The increase in lead poisoning on the American Continent is an indication that industrial control is either inefficient or not practiced. In practically all forms, lead may be toxic to the human organism—highly toxic as a molten vapor or a soluble, dusty or votatile form; slightly toxic as a sulphide or silicate. Its widespread distribution, therefore, in industry and manufacture warrants the taking of further steps to reduce the morbidity resulting from its use.

The exposure—The exposure to industrial leading in its various forms starts at the mine where it is ored, and from whence the hazard continues to the smelter and refinery where it is transformed into pig lead. From here it is shipped to other plants where it is changed by various methods into certain physical forms such as piping, or into compounds of lead. It may be oxidized by simple exposure to the air, and especially by a moderate degree of heat, into lead oxide, and by further oxidation into litharge or, by still further heating, into red lead. Again the pig lead may be changed into a carbonate by the Old Dutch or Carter process. Still other compounds such as lead sulphate, nitrate or tetraethyl lead may be formed by suitable processes. From the actual mining of the ore, smelting and refining and changing it into one of its many compounds, the lead worker is in constant exposure either through the actual handling of materials, or its accumulation on his clothing, skin and mucous membranes, or through the inhalation and swallowing of it in a dusty, spray, or vaporous state. After the compounds are made they are usually ground, sieved and packed in suitable containers. These operations create a special exposure in themselves.

Use in industry—In addition to the actual manufacture of these compounds, the use of pig lead and its compounds in industry adds a further exposure. For example, the pig lead may be melted and used as coating for pipes or telegraph cables. The pig lead itself oxidizes to a slight extent. The handling of the lead causes some of this oxide to become loosened and form a dust which may find the portals of entry of the body. Hence in many industries and trades, workers are constantly exposed to lead in one of three forms: a wet, pasty or spray form; a dry state; and in the form of a dust or vapor in the breathing atmosphere.

Mode of entrance—A brief summary of certain points made in Part I are in order here. It is an accepted fact that lead enters the system through the air passages and gastrointestinal tract. With the exception of tetraethyl lead, the skin is not significant as a point of entrance. While ingestion through the mouth (gastrointestinal tract) is of importance, the most important industrial mode of entrance is through the air passages.

Animal experiments have demonstrated that lead *dust* and *vapors* may be absorbed through the nasal mucous membranes as well as in the lungs. This indicates the necessity of stressing those methods that are concerned with the prevention of lead dust or vapor from getting into the breathing atmosphere. The futility of the ordinary respirator in accomplishing this purpose has been repeatedly demonstrated by the high incidence of lead poisoning even where this has been used consistently.

It is an easy matter to determine by chemical analysis whether or not a given atmosphere contains lead, and the quantity present—and a great extension of this practice is advocated in industrial plants using lead. Nothing less than a complete lead-free atmosphere for the operator to breathe should be aimed at. In the end, this can be accomplished for each worker by the use of a special respirator or helmet receiving a fresh supply of air from an outside or uncontaminated source.

B. General Considerations

The industrial control of lead poisoning depends on two factors:

1. A properly conceived plan that is comprehensive yet practical.
2. The adequate execution of that plan.

Discussion—The history of progress in industrial hygiene, accident prevention, and social and labor legislation is replete with examples of plans that have failed because of noncompliance with one or both of these factors. Either the fundamental plan has not been well conceived or the execution of it has been faulty. Legislation as a whip has accomplished less than education in promoting the welfare of the industrial worker. Large scale industry has coöperated better than small scale industry in executing plans for the improvement of healthful and safe conditions for workers. The laying down of arbitrary rules by governmental agencies frequently defeats its purpose. The word of the law may be obeyed but not its spirit. The general improvement of the health of the worker through shorter hours, increased wages, and greater leisure, as well as specific improvements in factory hygiene, are evidences that industry is alive to the economic value of humanitarianism.

Workmen's Compensation—The recognition of occupational diseases is gradually being extended into the workmen's compensation laws of the various states, provinces, and countries. Since lead poisoning is one of the most frequent forms of occupational diseases, and since its symptoms, complications and sequellae are so often serious, industry must become aware of the heavy burden it carried not only through large turnover, curtailed production or through compensation payments, but through the humane aspects of the case.

C. The Plan

Goal—The ideal to be aimed at in eliminating lead poisoning should be to prevent lead ingestion and lead absorption through the control of lead exposure.

Principally, the idea is to remove lead from actual or atmospheric contact by the adoption of:

- A. Various industrial means, such as
 1. The supply of a lead-free atmosphere from outside sources
 2. Automatic processes
 3. Confining cabinets or isolated spaces
 4. Air conveyances for lead in dry, vapor or spray forms
 5. Moist or oily processes
 6. Substitutes for lead
 7. High class factory or workplace hygiene
- B. Various personal means, such as
 1. Personal hygiene, observing particularly instruction to employees on how to prevent lead poisoning
 2. Medical supervision with frequent examinations specifically for lead exposure, lead absorption and lead poisoning
 3. Regulation of hours of labor involving lead exposure
 4. Limitation of the employment of youths, women, the delicate or sickly, and those who have previously suffered lead poisoning
 5. Prohibition of the employment of those showing increasing or marked evidence of lead absorption, any stage of lead poisoning, or a history of increased susceptibility, or marked symptoms in previous attacks

The more elusive of the above items are next discussed under the two following headings:

Standards for Workplace Hygiene

Standards for Personal Hygiene

The words "shall" and "should" are advisedly used in these standards to denote compulsion or admonition respectively.

STANDARDS FOR WORKPLACE HYGIENE

1. *Age*—No worker less than 21 years of age shall be permitted to engage in any occupation where lead is used, *i. e.*, subjected to lead exposure.

The general clinical conclusions of appointed surgeons in the various lead factories would be, we believe, that the susceptibility of young persons is at least twice that of adults, and there is some ground for supposing that the tissues of an adult, when growth has ceased, more readily adapt themselves to deal with the absorption and elimination of poisonous doses than do the tissues of a young person.—Legge and Goadby, *Lead Poisoning and Lead Absorption*, 1917, p. 35.

2. *Sex*—No female under 45 years of age should be permitted to handle any dry substance or dry compound containing lead in any form where the lead content is in excess of 2 per cent.

Figures showed females to be attacked about twice as frequently as males.—Thomas M. Legge, *J. Roy. Soc. Arts*, 4007: 1028 (Sept. 6), 1929.

3. *Workplace*—Every employer shall without cost to his employees provide and maintain for the protection of his employees who are engaged in a work or

process involving lead exposure, workrooms or workplaces which comply with the following:

(a) So illuminated that there are at least 4 foot candles of light on all working planes where the air is breathed.

(b) So ventilated and arranged that there are at least three complete exchanges of air per hour, using normal outside air.

(c) All workrooms shall be provided with a smooth floor permitting easy removal of dust by vacuum cleaning, flushing, the use of oiled mops, or sweeping with wet sawdust or other wet material, or other means to lay dust. Dry sweeping of floors is prohibited.

(d) The walls of workrooms shall be smooth and shall be painted, varnished, whitewashed, cleaned or otherwise freed of dust or smudge at least once annually.

Dust may be prevented from accumulating upon walls by vacuum cleaning, flushing, oil mopping, or adequately ventilating outside of work-hours. Dry sweeping of the walls is prohibited.

(e) Windows and lighting fixtures shall be kept clean.

(f) Machinery, benches, hoods, ovens, etc., shall be frequently freed of dust accumulation.

(g) No scrap, tailings or materials containing lead in dry form shall be allowed to accumulate on the workroom floor.

4. Materials—

(a) All dusty materials creating a condition of lead poisoning should be kept moist where possible.

(b) All dusty materials, creating a condition of lead exposure, should be kept covered and, where it can be done without actual interference with the work process, they should be connected with adequate exhaust systems and ventilation. Special regulations for tetraethyl lead, its compounds, mixtures and dilutions shall be taken as recommended by the U. S. Public Service (*Pub. Health Rep.* 43:3147-3149 (Nov. 30, 1928)).

5. Processes—The wide variety of processes makes it impractical to specify the precautions to be taken for each, but certain general rules (indicated by the word "shall") and principles (indicated by "should") are laid down for the handling of lead so as to prevent lead exposure.

(a) All work shall be conducted and such adequate devices provided and maintained by the employer as to protect the employee from lead exposure.

(b) Wherever possible, automatic processes should be substituted for hand processes.

(c) Wherever lead is melted, the melting pot should be provided with a hood connected with an effective vent to the exterior.

(d) All receptacles such as crane buckets, boxes, barrels, cars, conveyors,

chutes, hoppers, dumps, or other containers when creating a condition of lead exposure shall be equipped with a hood or other close-fitting cover connected with an air exhaust of sufficient character to prevent the escape of lead in dust form to the surrounding atmosphere.

(e) All crushing mills, grinding mills and sieving machines operating on lead containing material in a dry state shall be connected with an efficient air exhaust and dust collecting system, or be completely confined.

(f) All vats containing solutions of soluble lead salts for boiling should be protected by suitable hoods.

(g) All shaking, mixing, dusting, spraying or otherwise frequent manipulating of dry materials containing lead shall be performed either in a cabinet, or under an exhaust equipment, or in a special room with mechanical exhaust ventilation, and, in case it is necessary that the worker be located in, or is required frequently to enter such cabinet, equipment, or room, he shall be provided with a form of helmet or respirator which draws air from an outside source.

(h) All packing of dry material containing lead shall either be carried on by a type of packing machine that retains or removes all lead dust, or the worker shall be equipped as specified in (g) above.

(i) All workers when required to be employed temporarily in or near lead dust, spray or fumes shall be equipped as specified in (g) above.

(j) All operations which through speeding up increase the exposure to lead dust, spray, and fume should be slowed down or discontinued at periodic intervals.

(k) All workers not engaged in work involving a lead exposure should be completely separated therefrom.

(l) Lead-containing dusts, sprays, fumes, or vapors should not be permitted to escape to neighboring premises.

(m) At least daily inspections should be made of all work conditions and apparatus that pertain to the prevention of lead exposure.

(n) The lead exposure associated with the various processes of an industry should be accurately measured from time to time, so as to give an indication of the importance of the hazards, and so as to evaluate the measures taken for the reduction of such hazards.

6. Sanitary provisions—

(a) The employer shall provide a separate washroom equipped with—

(1) One lavatory basin for every five employees, fitted with waste pipes and two spigots conveying hot and cold water or the equivalent.

(2) One nail brush, soap and a clean towel for each employee (or a sufficient number of paper towels).

(3) Ten minutes' time allowance at the employer's expense for each

employee for the use of the washroom before lunch and at close of the day's work. The washing should be supervised and records of the same kept.

(4) One shower bath for every five employees. The baths should be approached by wooden runways; be provided with wooden floor gratings; be supplied with hot and cold water; and kept clean.

(b) The employer shall provide toilets, urinals and water closets in strict accordance with the official sanitary regulations governing factories or other workplaces in the community.

(c) The employer shall provide a dressing room adequately heated, separate from the workrooms, equipped for each employee with a double sanitary locker or two sanitary lockers, or two individual ceiling hangers with cord-pulls—in either case the one for his street clothing and the other for his work clothing.

(d) The employer should provide an eating room separate from the workroom with sufficient tables and seats, and keep same clean.

(e) The employer shall provide food lockers in the eating room which shall be kept under lock and key held by the foreman or other supervisor who shall surrender key at lunch time and quitting time only, and only when satisfied that the given employee has complied with the following sanitary regulations:

Each employee in a process presenting possible lead exposure shall, before *eating*—

(1) Thoroughly dust or exchange the outer clothing, or place clothing not subjected to workroom lead exposure over same.

(2) Wash the hands and face thoroughly.

(3) Clean the finger nails.

Each employee in a process presenting possible lead exposure shall, before *quitting* the workplace, carry out (1), (2), and (3) and also

(4) Dust and leave his work clothing in the locker or hanger provided therefor.

(5) Take a complete shower, sponge or scrub bath.

(6) Don street or other wearing apparel which has not been subjected to lead exposure.

(f) The employer should supply one pair of overalls and one jumper for each employee and should repair and renew such clothing when necessary and wash the same at least once each week.

(g) The employer shall supply a sanitary and potable drinking water, regular and copious use of which should be encouraged.

(h) The employer shall post in a conspicuous place, *Rules* (in English) for *Personal Hygiene* (see below), and in the several languages to corre-

LEAD POISONING

spond to the comprehension of the various employees, provided five or more of a given language are employed. Each applicant upon hiring for work in a process subjecting him to lead exposure shall be supplied with a copy of *Rules for Personal Hygiene*:

RULES FOR PERSONAL HYGIENE

1. Do not go to work on an empty stomach.
Do not put fingers in the mouth.
Do not take food into the workroom.
Do not eat food in the workroom.
Before eating and before leaving work, thoroughly wash the face, arms and hands with soap and water, blow out the nose and rinse out the mouth.
2. Take a bath daily. Cleanliness is one of the best preventives of sickness.
3. Do not chew tobacco while at work, for in the handling of the tobacco with dirty hands the dust may be carried by your fingers into your mouth.
4. Do not drink alcoholic liquors. Alcohol favors lead poisoning.
5. Keep your finger nails clean and cut short so that the dust cannot collect under and around them.
6. It is better not to wear a mustache or beard as these collect dust. If worn it is better to keep them cut short and to wash them thoroughly every day.
7. Keep your bowels open. Take a dose of Epsom salts once a week.
8. Dry sweeping and dusting about the workplace is prohibited (See Foreman for methods of cleaning up).
9. Wear a respirator or helmet where Foreman instructs you.
10. If ill consult a physician at once.

MEDICAL SUPERVISION

1. Medical supervision should be obtained for all workers subjected to lead exposure.
2. Efforts toward organizing medical services to this end should be made. Small groups of workers subject to lead exposure should make arrangements with clinics or hospitals having adequate laboratories, or with other industrial units, so as to command adequate medical and laboratory supervision.
3. Only competent medical men who are directly interested in promoting industrial and public health should be engaged to control the medical supervision of lead exposed workers.
4. All workers should be examined at the time of hiring. The examination should include at that time findings of possible lead absorption or lead poisoning from previous exposure since workers tend to follow the pursuits with which they are most familiar. No applicant should be employed who shows any evidence of lead absorption or lead poisoning or any definite heart, kidney, lung or arterial disease, anemia, neurological conditions, marked oral sepsis, or gastrointestinal disorder.

5. Each worker engaged in a lead operation of any kind should be medically examined weekly.

(a) The examination should be conducted in a room separated from the workroom and especially provided for that purpose.

(b) The examination should consist of:

(1) An inquiry into incidental illnesses including accidental mishaps that may have arisen during the preceding week

(2) A careful inquiry into any present health complaints

(3) A physical examination with particular reference to lead poisoning in any of its stages or phases

(4) A laboratory examination which should consist of a red cell count, white cell count, a hemoglobin estimation and a differential blood examination with particular reference to the detection of stippled or other abnormal cells (see below)

6. A monthly dental examination is recommended.

7. Three criterions for changing the employment of a worker are suggested:

A. *Upon blood findings—*

(a) The presence of reticulosis, stippled cells (basophilia), or basophilic aggregation in increased amounts (The committee plans to inquire into the technic of various methods of establishing these findings, and with a view of placing one or more of the technics upon a quantitative basis.)

(b) A red cell count well below normal

(c) A hemoglobin estimation well below normal

(d) A gradually changing condition of the red blood cells when followed through four blood examinations, made at intervals of one to seven days based upon the probable intensity of exposure, as evidenced by—

(1) An increasing stippled (basophilic) cell count

(2) An increasing presence of other abnormal cells

(3) A progressive reduction in the red cell count

(4) A progressive reduction in the hemoglobin

B. *Upon physical findings—*

(a) Gradual loss of weight, appearance of pallor, tremor or hypotension

(b) A reduction in the hand and wrist strength tests after four consecutive (weekly) examinations as shown by a progressive change in a record charted for such strength tests.

C. *Upon symptomatology—*obviously, upon any array of symptoms indicative of lead poisoning in any of its stages; but note that some workers may deny symptoms in order to hold their jobs.

8. All cases of lead poisoning in any stage shall be reported to the proper

city, state, provincial or other governmental authority according to respective laws or regulations covering this matter.

REGULATION OF HOURS OF LABOR

A shorter work day or shorter work week would diminish the time of exposure and thus reduce the possibility of lead poisoning. It is therefore recommended as a standard that all men exposed to any of the leading hazardous lead operations* be permitted to adopt one of the following plans:

1. Work 5 days a week, at 8 hours per day (40 hours)
2. Work 7 hours a day, $\frac{1}{2}$ day on Saturday (39 hours)
3. Change at monthly intervals from a lead exposed to a non-lead exposed operation.

*As stated above, the committee expects to prepare a list of the industries and trade processes involved in significant lead exposures.

B. BIBLIOGRAPHY

The *Bibliography* prepared by the committee consists of an alphabetical list of approximately all articles published during the period January 1, 1928, to December 31, 1928, on the subject of lead and its effects on human beings, the titles of which have been found in the following publications: (1) *Bibliography of Industrial Hygiene, International Labour Office*; (2) *Journal of Industrial Hygiene*; (3) *Quarterly Cumulative Index Medicus*; (4) *Chemical Abstracts*; (5) *Journal of the American Medical Association*; (6) *Public Affairs Information Service*; (7) *American Journal of Public Health*; (8) *Miscellaneous*.

The emphasis is largely on the industrial aspects, but there are other articles which have been included because it was felt they might throw some light on the subject at hand. Roughly, it may be said that the articles included encompass the subjects of Chemistry, Toxicology, Clinical Aspects, Analytical Material, Industrial Processes, and General Topics.

The *Bibliography* has been prepared primarily for the committee in relation to its work, particularly in regard to the devising of Standards such as those presented in the preceding Section (A). The entire *Bibliography* can, however, be made available to anyone interested, under certain conditions.*

The *Bibliography* includes 265 articles as it now stands to which some more for 1928 may yet be added. These are divided roughly into the following countries of origin: 70 American, 36 British (this includes British Empire), 80 German and Austrian, 18 French, 12 Italian, 20 Russian, 1 Polish, 1 Hungarian, 8 Japanese, 3 Belgian, 3 Swiss, 2 Miscellaneous, and 11 Uncertain.

Abstracts are obtainable at the time of this writing (Sept. 28, 1929) for 112 of the listed titles for 1928. These abstracts have been secured in two ways: (1) From printed abstracts already published, as in the following journals: *Chemical Abstracts*; *Physiological Abstracts*; *Biological Abstracts*; *Journal of Industrial Hygiene*; *American Journal of Public Health*; *Journal of the American Medical Association*; (2) Original Abstracts made by the committee.

Apparently abstracting journals are considerably in arrears even for many of the major articles which appeared in the literature for the year 1928. In some instances the original journals have also proved unobtainable by the committee. However, the committee hopes to secure abstracts for most, if not all, of the articles cited in the *Bibliography*.†

*The *Bibliography* comprises approximately 27 pages with 10 items to the page, 4 lines each, giving the author, title, journal or place, page(s), and date of publication, whether or not abstracts are available and, if so, where.

All requests for bibliographic material or suggestions concerning it should be addressed to Dr. Carey P. McCord, Secretary, Industrial Hygiene Section, A. P. H. A., 34 West Seventh Street, Cincinnati, O.

†The committee can supply copies of abstracts at a cost of 5 cents each for those not exceeding half a page, double space (the majority), and 10 cents for those longer than this. Citations to printed abstracts not exceeding five in number can be furnished free, and more than this at the actual cost of typing.

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