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UNITED STATES PUBLIC HEALTH SERVICE

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THE USE OF TETRAETHYL LEAD GASOLINE IN ITS RELATION TO PUBLIC HEALTH

PREPARED BY DIRECTION OF THE SURGEON GENERAL

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INTRODUCTION

Early in 1923 lead tetraethyl began to be used in gasoline in an endeavor to increase the efficiency of the gasoline as a motor fuel. The possible danger from such wide distribution of a lead compound aroused fear on the part of those concerned with the public health, and these fears were intensified when fatal poisoning occurred in the manufacture and mixing of the concentrated tetraethyl lead itself in Deepwater, N. J., Dayton, Ohio, and Bayway, N. J. As a consequence of such apprehensions, the distribution of tetraethyl lead was stopped on May 5, 1925, and the sale of gasoline containing tetraethyl lead was thereby generally discontinued.

On May 20, 1925, a conference called by the Surgeon General of the Public Health Service met to consider the possible health hazards from the manufacture, distribution, and use of this lead compound as a substance to be added to gasoline. The proceedings of this conference have been published as Public Health Bulletin No. 158. Those in attendance generally recognized that the production and handling of the concentrated tetraethyl lead involved a distinct industrial hazard, and attention was principally focused on the question which remained open, as to the dangers to the public, automobile drivers, and garage workers, from the general use of lead-containing gasoline. Reports were made to the conference, of studies which had been conducted at three different places to elucidate this question—at the Bureau of Mines laboratory at Pittsburgh, reported by Dr. R. R. Sayers; at the department of industrial hygiene of Columbia University, New York City, by Dr. F. B. Flinn; and at the laboratory of the Ethyl Gasoline Corporation, Dayton, Ohio, by Dr. R. A. Kehoe. The studies at the first two of these institutions were experimental investigations on animals; the series at the Bureau of Mines showed no effect from the exhaust gases from an engine using gasoline containing tetraethyl lead in commercial proportions when the carbon monoxide was kept below 0.02 per cent, but prolonged exposure to unburned vapor containing 0.3 per cent of ethyl gasoline caused lead storage. The New York studies indicated storage of lead from skin application of 1:1,000 tetraethyl lead in gasoline, also from the inhalation of the fumes from such a dilution; but it was agreed by both sets of workers that no definite idea of the reality of the hazard could be obtained without human experience under practical working conditions. The studies at Dayton included human observations, but were not sufficient for conclusions to be drawn therefrom. After considerable discussion of the various

phases of the problem the conference adjourned, having agreed upon the following resolution:

It is the sense of this conference that the Surgeon General of the United States Public Health Service appoint a committee of seven recognized authorities in clinical medicine, physiology, and industrial hygiene to present to him, if possible by January 1 next, a statement as to the health hazard involved in the retail distribution and general use of tetraethyl lead gasoline motor fluid; and that this conference indorses as wise the decision of the Ethyl Gasoline Corporation to discontinue temporarily the sale of ethyl gasoline; that the investigation shall be paid for exclusively out of public funds; and that the results of this investigation shall be reported back to a public conference called for the purpose by the United States Public Health Service, at which labor shall be represented.

The Surgeon General appointed, as members of this committee, the following:

A. J. Chesley, M. D., St. Paul, Minn.
Executive health officer, Minnesota State Board of Health.

David L. Edsall, M. D., Boston, Mass.
Dean of the Medical School and of the School of Public Health, Harvard University. Formerly professor of clinical medicine at the University of Pennsylvania and at Harvard University.

William H. Howell, Ph. D., M. D., Baltimore, Md.
Professor of physiology, School of Hygiene and Public Health, Johns Hopkins University. Formerly professor of physiology at the University of Michigan and at Johns Hopkins Medical School.

Reid Hunt, M. D., Boston, Mass.
Professor of pharmacology, Medical School, Harvard University. Formerly professor of pharmacology, Hygienic Laboratory, United States Public Health Service.

Walter S. Leathers, M. D., Nashville, Tenn.
Professor of preventive medicine, Vanderbilt University. Formerly executive health officer, Mississippi State Board of Health.

Julius Stieglitz, Ph. D., Chicago. Ill.
Professor of chemistry, University of Chicago.

Charles-Edward Amory Winslow, M. S., New Haven, Conn.
Professor of public health, Medical School, Yale University. President, American Public Health Association.

This committee met on June 15 and organized, with Doctor Howell as chairman. L. R. Thompson, surgeon in charge of the office of industrial hygiene and sanitation of the United States Public Health Service, acted as the secretary to the committee. The general scope of the investigation was agreed upon, and at the second meeting of the committee, on June 29, 1925, J. P. Leake, surgeon, United States Public Health Service, was intrusted with direct charge of the investigation. On October 16, 1925, Doctor Leake reported to a meeting of the committee the results of the investigation up to that time, and on December 22, 1925, the committee met to consider the full report of the investigation by Doctor Leake. The last meeting of the committee was on January 17, 1926, when the final report of its findings were drafted and signed. This report (pp. 103–115 following the detailed report) summarizes the investigation and draws conclusions.

On January 19, 1926, a second public conference met at the call of the Surgeon General to hear the report of the committee. The following were in attendance:

American Federation of Labor:
A. J. Berres.
American Institute of Chemical Engineers:
H. E. Howe.
American Oil Co.:
John M. Klein.
Anglo American Oil Co.:
H. S. Tegnor.
Baltimore City Department of Health:
Dr. C. Hampson Jones, *Commissioner.*
F. A. Korff.
Bureau of Aeronautics, Navy Department:
Comdr. E. E. Wilson.
Bureau of Chemistry, Department of Agrilcuture:
Dr. Erich Schwartze.
Bureau of Mines, United States Department of Commerce:
Scott Turner, *Director.*
Dr. R. R. Sayers.
W. P. Yant.
A. T. Coumbe, jr.
Bureau of Standards, Department of Commerce:
H. K. Cummings.
Calco Chemical Co.:
A. R. Norton.
Chemical Warfare Service, United States War Department:
C. R. Alley.
Columbia University:
Frederick B. Flinn.
Detroit City Department of Health:
Henry F. Vaughn, *Commissioner.*
E. I. du Pont de Nemours & Co.:
W. F. Harrington.
Charles K. Weston.
Ethyl Gasoline Corporation:
E. W. Webb, *President.*
A. M. Maxwell.
Dr. Robert A. Kehoe.
Geological Survey, Department of Interior:
George Otis Smith, *Director.*
Harvard University:
Dr. Alice Hamilton.
Institute of Government Research:
J. A. Tobey.
Mellon Institute:
W. A. Gruse.
National Research Council:
Dr. Victor Vaughan.
Nation's Health:
Dr. F. L. Rector.
New York State Department of Health:
Dr. Augustus Wadsworth.

New Zealand Department of Health:
Doctor Watt, *Deputy Director General.*
Ohio State Department of Health:
Dr. John E. Monger.
Ohio State University:
Dr. E. R. Hayhurst.
Philadelphia City Department of Health:
Dr. William C. Robinson.
Society of Automotive Engineers:
Harry Horning, *President.*
Standard Oil Co. of Indiana:
Dr. Frank R. Morton.
R. J. Fellingham.
Standard Oil Co. of New Jersey:
F. A. Howard.
United States Public Health Service, Treasury Department:
Surg. Gen. H. S. Cumming, chairman of conference.
Asst. Surg. Gen. A. M. Stimson.
Surg. G. W. McCoy, director, Hygienic Laboratory.
Surg. J. P. Leake.
Surg. L. R. Thompson.
Workers' Health Bureau:
Mrs. Grace Burnham.

Doctors Howell, Chesley, Hunt, and Leathers of the committee were also in attendance. The report was read by the chairman of the committee and adopted unanimously by the conference. A resolution was also adopted expressing the sense of the conference that the investigation of industrial hazards in the United States should be concentrated in the United States Public Health Service, and the necessary funds be given that organization with which thoroughly to prosecute these investigations. A question was also raised as to whether the possible effect of tetraethyl lead gasoline on the sterility of the race was taken into consideration in the investigation. This was answered by Doctor Leake in a statement that questions in regard to sterility were asked of each individual in the investigation and there was no indication of any sterilizing effect caused by the exposure.

In accordance with the recommendations of the committee, suggested regulations were drawn up by the Public Health Service in regard to the manufacture, distribution, and use of tetraethyl lead and mixtures containing tetraethyl lead for adoption and enforcement by the several States. These proposed regulations form the final section of this bulletin. After having been submitted in draft to the departments of health of the several States they were presented at the Conference of State and Territorial Health Officers with the Surgeon General on May 25, 1926. It was there explained that the last set of regulations, concerning garages and inclosed filling stations, is directed chiefly toward protection against carbon monoxide poisoning. Helpful suggestions regarding this set of proposed regulations have been received from Prof. A. C. Willard, of the department of mechanical engineering, University of Illinois, but they are mainly based on observations made during this investigation.

INVESTIGATION OF HEALTH HAZARD FROM TETRAETHYL LEAD GASOLINE

By JAMES P. LEAKE, LAWRENCE KOLB, LOUIS SCHWARTZ, GLEASON C. LAKE, CHARLES ARMSTRONG, and W. T. HARRISON, *Surgeons*, CLAUDE W. MITCHELL, *Passed Assistant Surgeon*, WILLIAM MANSFIELD CLARK, *Professor of Chemistry*, ELIAS ELVOVE, *Chemist*, C. G. REMSBURG, *Assistant Chemist*, CONRAD KINYOUN, *Assistant Bacteriorologist*, J. J. BLOOMFIELD, *Assistant Physical Chemist*, WALLACE HALL, *Assistant Chemist*, and WILLIAM A. SIMKINS, *Junior Chemist*, *United States Public Health Service*

SECTIONS OF TEXT

LIST OF TABLES

To accompany Section II:

SECTION I

SCOPE AND METHOD

This investigation [1] was undertaken to determine what health hazard, if any, is involved in the retail distribution and general use of tetraethyl lead gasoline as an automobile fuel. For this purpose human subjects were studied who had for a considerable period been exposed in the actual distribution and use of this gasoline.

Since by the resolution adopted on May 20, 1925, by a conference called by the Surgeon General of the United States Public Health Service to consider this question, a report was desired by January 1, 1926, it was believed that more conclusive data could be obtained by examining subjects who had already been exposed to such possible hazard for a considerable time than by beginning exposure of other groups who could be observed for only a very few months. Such subjects were found in southwestern Ohio, where ethyl gasoline (the commercial name of gasoline containing tetraethyl lead) was first generally used, and where it is still in use.

Since very slight deviations from the normal were to be looked for, the examination of control subjects, similar to the exposed in all respects except that of exposure to ethyl gasoline, was necessary. Also, in order to insure the sufficiency of the method, it was thought advisable to examine, in the same way, subjects who were exposed to a definite lead hazard but who were not incapacitated from work by lead poisoning; if the method was sufficient, lead absorption or some slight evidence of lead intoxication should be discovered among such persons.

All the subjects were adult males—252 in number. They were divided into five groups—A, B, C, D, and E. Group A comprised 36 men who used automobiles propelled by gasoline other than ethyl gasoline and who were exposed to exhaust fumes to a degree at least equal to that of the general public. Group B comprised 77 car users similar to Group A, except that the motor fuel which they used

[1] Aside from the helpful direction of the committee, continual assistance during the investigation was derived from Surgs. G. W. McCoy and L. R. Thompson. Suggestions from Dr. Joseph C. Aub, of Harvard Medical School, were of assistance in outlining the general plan of examination; for the quantitative method of analysis for lead we are particularly indebted to Dr. Lawrence T. Fairhall, of the Harvard School of Public Health, Surg. R. R. Sayers, U. S. Public Health Service, W. P. Yant, of the U. S. Bureau of Mines, and Dr. Graham Edgar, of the Ethyl Gasoline Corporation. The precipitating apparatus used for part of the dust studies was made for us by Philip Drinker, of the Harvard School of Public Health. The stool examinations for intestinal parasites in cases showing anemia are due to Prof. Ch. Wardell Stiles and Laboratory Aide Alma J. Speer, of the division of zoology, Hygienic Laboratory. The tabulations and compilations were made by a force of statistical clerks under the supervision of Associate Statistician R. H. Britten.

was ethyl gasoline. Group C comprised 21 garage workers and gasoline handlers (filling-station men, tank-truck drivers, etc.) exposed to gasoline other than ethyl gasoline. Group D comprised 57 garage workers and gasoline handlers similar to Group C, except that the exposure was to ethyl gasoline. Group E comprised 61 men exposed to a definite industrial lead hazard.

The subjects of Group A were employees of the municipality of Dayton, Ohio, who used, for a considerable period of each day, cars belonging to the city which were kept in the municipal garage and filled there with ordinary gasoline. The subjects of Group B were employees of a public-service corporation in the same city. This corporation supplies electricity to a large area in southwestern Ohio, and gas and steam heat and power within the city of Dayton. Ethyl gasoline had been used to the exclusion of all other gasoline in the cars of this corporation since July 1, 1923, and is still in use. As will be shown in tables accompanying section II of this report, many of these employees drove for the greater part of the day on account of the distances to be covered. The subjects of Group C were garage employees of the Dayton municipal garage, above mentioned, employees of a public garage in Cincinnati (herein called the Cincinnati control garage) where cars were serviced and repaired which did not use ethyl gasoline, and filling-station employees and tank-truck drivers of gasoline companies in Dayton not handling ethyl gasoline. The subjects of Group D were garage employees of the Dayton public service corporation, mentioned above, employees of a garage in Cincinnati (herein called the Cincinnati test garage) in which almost all the cars handled since November, 1923, used ethyl gasoline, and filling-station men and tank-truck drivers of two affiliated gasoline companies, one in Dayton, the other in Cincinnati, supplying ethyl gasoline. The subjects of Group E were employees in two plants, one on the Ohio River watershed and the other on the Great Lakes watershed, who were exposed in greater or less measure to the hazard of lead dusts. In each of these plants numerous cases of lead poisoning, including some cases of lead encephalopathy, had occurred within the past few years.

The men examined from the two plants with the high lead hazard were apparently not a selected group but fairly represented the average of the departments in length of employment, exposure, and other respects except that a few of the foremen and subforemen, appreciating the value of the examination, applied for it. The other subjects of this group were picked at random by the foremen of the different departments.

At no time has the amount of ethyl gasoline sold in either Dayton or Cincinnati exceeded 5 per cent of the total gasoline currently sold there. Only one of the 61 subjects of Group E had ever used ethyl gasoline; the amount used by this man was negligible.

The plan of work included a clinical examination with a careful history of each person, hemoglobin estimation, red-cell count, count for stippled cells, and examination of a specimen of feces for lead. No examination of the urine other than for color, specific gravity, reaction, albumin, and sugar was made, since the slight degrees of lead intake which were to be looked for would probably be shown more strikingly in feces than in urine. Aside from possible effects from lead in the subjects examined, each person was questioned confidentially as to any rumored injuries from ethyl gasoline which he might have heard of in the districts where this gasoline was used. In order to secure an idea of the amount of ventilation and of contamination of the air by exhaust gases and evaporation of gasoline in the garages where exposure took place, a few estimations of carbon monoxide content and of lead content in sweepings and in the air were made. The examinations in Dayton were made from October 6 to 13, inclusive, and October 29 to November 2, inclusive. Examinations in Cincinnati were made on November 4 and 5. On account of cool weather the ventilation in all the garages during these periods was on a winter basis. The number of doors and windows open during the peak periods of air contamination could hardly have been less even in the severest winter weather.

The schedule which was used for the clinical examination was mimeographed on cards 8½ by 11 inches. Four cards were used for each person, one for each of the four examining physicians.

The first card contained the following items:

Name.
Age.
Residence.
Right or left handed (for interpretation of muscle tests).
Marital status.
Ages of children.
Place of work.
Present occupation (exact description and dates of this and previous employment at the same job).
Hours per day lead or gasoline hazard.
Total time with present employer.
Birthplace.
Other places lived in for one month or more, with approximate dates.
Previous occupations, with approximate dates and length of employment.
Previous lead hazards, with dates and duration.
Present lead hazards, with duration.
Use of employer's car.
Use of family car, length of time and amount used, and amount of ethyl gasoline used.
Previous illnesses.
Use of bismuth (which had been found to interfere possibly with the quantitative examination for lead in feces).
Significant family history in parents, brothers, or sisters.
Examiner's initials, and date.

The second card contained these items:

Case number.
Examiner's initials and date.
Sleep:
- Hours in bed.
- Restful or disturbed.
- Nocturia.

How much milk or cream per day.
How much water per day.
Bowel movements:
- How frequent.
- At what hour.
- Use of laxative.
- Tendency to constipation—For how long.

Teeth:
- When brushed.
- Last trip to dentist.

Usual weight.
Best weight (heaviest).
General health.
Memory.
Drowsiness.
Insomnia.
Twitching.
Rate of tiring as compared with previous.
Muscular strength as compared with previous.
Dyspnœa.
Palpitation.
Precordial pain.
Headaches.
Eye trouble.
Taste in mouth: Metallic.
Pains in joints.
- In muscles.
- In abdomen.

Appetite.
Nausea.
Vomiting.
Eructations.
Loss of consciousness.
Numbness.
Other paraesthesias.
Other complaints.
Tests for muscle strength:
- Extensors of right wrist—first trial; second trial; third trial.
- Flexors of right wrist—first trial; second trial; third trial.
- Extensors of right middle and ring fingers—first trial; second trial: third trial.
- Flexors of right middle and ring fingers—first trial; second trial; third trial.
- Flexors of left middle and ring fingers—first trial; second trial: third trial.
- Extensors of left middle and ring fingers—first trial; second trial; third trial.
- Flexors of right wrist—first trial; second trial; third trial.
- Extensors of left wrist—first trial; second trial; third trial.

The third card contained the following items:

Case number.
Examiner's initials.
Date.
Height.
Weight.
Color of skin:
    Pallor.
    Slight yellowness.
    Sclera.
General appearance.
Posture.
Musculature.
Nutrition.
Skin.
Superficial glands and nodes.
Romberg sign.
Tremors:
    Tongue.
    Eyelids.
    Fingers.
Eyes:
    Use of glasses—Worn during examination.
    Vision—R. 15/ ; L. 15/
    Function of muscles.
    Near or far sighted.
    Field of vision.
Nose.
Ears.
Hair.
Tongue.
Throat.
Teeth, condition:
    Gums—
        Cleanliness.
        Pyorrhea.
    Lead line, exact appearance, location.
Temperature.
Pulse, sitting.
Blood pressure:
    Sitting—systolic; diastolic.
    Recumbent—systolic; diastolic.
Heart.
Lungs.
Abdomen.
Liver.
Spleen.
Kidneys.
Upper extremities.
Lower extremities.
Rectum.
Genitalia.

Reflexes:
- Patellar.
- Achilles.
- Biceps.
- Olecranon.
- Radial.
- Abdominal.
- Pupillary.

Pupils:
- Size.
- Regularity.

Sensation:
- Pain.
- Touch.
- Heat.
- Cold.

The fourth card contained the following items:

Number.
Physician.
Date.
Urine:
- Color.
- Specific gravity.
- Reaction.
- Albumin.
- Sugar.

Blood:
- Hemoglobin (Dare instrument No. —).
- Red cells per cubic millimeter—
  - Pipette number.
  - Counting-chamber No. —.
  - Initials of examiner.
- Four slides for stippling study.

Feces sample:
- Jar given (date and hour).
- Collected (date and hour).
- Five cubic centimeters formalin added (date and hour).
- Shipped to Hygienic Laboratory (date).

One of the most important phases of the study was that the identity of the subjects as regards their exposure to ethyl gasoline was not disclosed to any of the many individuals taking part in the study except to the physician who took the industrial history. The plan by which this "blind" examination was secured was as follows:

The numbers from 1 to 1000 had been distributed at random and put down according to this random distribution on 25 sheets, 40 numbers to a sheet. At the time of the examination the subject first came to the physician who took the industrial history. This physician was also in charge of the investigation. He entered the name of the subject on his own schedule card (the first card of the four described above) and then copied the name opposite the first unassigned number of the series of numbers distributed at random on the 25

sheets. Thereafter throughout the examination the subject was known only by this number assigned to him. The number, but not the name of the subject, was placed on the schedule cards used by each of the other three physicians and on the specimens and slides sent to the laboratory for examination. The only key whereby the industrial and exposure history could be connected with the results of an examination consisted in the 25 sheets with their series of irregularly distributed numbers. The same series was long enough to give distinguishing numbers for the various samples of dust, gasoline, etc., examined during the investigation.

The first physician, who was the only person at all cognizant of this key of numbers corresponding to the names and industrial histories, worked in a room separate from the other physicians for all examinations except part of the E series, and in this small part he was out of hearing distance of the one other physician who worked in the same room with him.

In the case of persons belonging to Group E (those with recent and present exposure to lead dusts) the employees of one of the plants were examined at the same time as persons belonging to the other groups, when the examining physicians, except the first one, were not aware that persons with the heavy exposure were being introduced for examination. At the examination of employees of the other plant the lead hazard was obvious to all, but some of the subjects introduced were from parts of the establishment where no lead was used, in order to serve as controls.

The scheme of "blind" examination was cooperated in by all concerned, and no attempt was made to learn the exposure history of the subjects by those who were supposed not to have this information in making their part of the examination. The first physician removed buttons or any removable symbols from the subjects which would indicate their employment or exposure, and in explaining to them the purpose, value, and confidential nature of the examination cautioned them against disclosing their employment as related to exposure. The same plan of nondisclosure of identity or exposure was successfully followed through the examination for stippling in blood cells and for lead in fecal and other specimens.

It is realized that this method deprived the examination of a certain comprehensiveness which the usual clinical examination should have in that the examining physician should be in possession of all the facts regarding exposure. Nevertheless, for the purpose of this investigation, the "blind" way in which these studies were conducted was essential, and it is believed that this method, together with the confidential relation which existed in almost all cases between the subject and each physician examining him, forms a most important feature of this report.

SECTION II

CLINICAL STUDIES, INCLUDING INDUSTRIAL HISTORIES OF SUBJECTS, HEMOGLOBIN ESTIMATIONS, AND RED-CELL COUNTS

It was planned that each clinical examination, as detailed in the schedules above given in Section I, would consume two hours. This, with four physicians examining, would allow one new subject to be introduced for examination each half hour. With increasing practice in the routine of the schedules on the part of the examiners and with the ready response of those examined to questions and directions, it was found that an examination could be completed in a little over an hour.

It is believed that the industrial histories could hardly have been more complete. A triple check was provided to secure the story of any occupation which might involve a lead hazard. Besides detailed questions as to the present employment, the subject was asked the different places where he had lived, the time of each residence, also a complete industrial history as to all jobs held, their nature and duration, and any exposure to lead which might have been involved. These questions as to occupation and location served as a check the one on the other. Direct questions were asked also as to any previous lead hazard, with dates and duration. To serve as an aid to the subject's memory, the following list was read over to him while he watched the list as read: Lead mining or smelting; plumbing; making or handling lead objects, tin foil, solder, or Babbitt metal; brass founding; printing; making white or red lead; pottery work; putting on glazes or enamels; making storage batteries; painting; making or handling paints; lithograph transferring; polishing cut glass or brass; putting in window glass; making rubber; vulcanizing; making shade cloth; lead calking. A nonindustrial exposure to lead, such as painting, putting in window glass, or soldering at home, which the ordinary householder does, or the ingestion of food or drink which has been in contact with lead, was neglected, since this would be impossible of estimation and might be taken as roughly uniform throughout the groups; Groups A, B, C, and D, in which previous lead exposure might be important were uniform as to location and social status. With the method of questioning used it was surprising how frequently a history of industrial lead exposure other than to ethyl gasoline was elicited. Only 106 out of the 191 in Groups A, B, C, and D who were not at the time of the examination exposed to a serious lead hazard failed to give a history of previous exposure. Each of these exposures, however, was so slight and of such short duration or so remote that but little postitive evidence was gained as a result of this examination. Taking all the factors into account these exposures were grouped as very slight (present

and past), slight (past), and moderate (past) for Groups A, B, C, and D. The very slight exposures were nearly negligible. For Group E, those with recent and present exposure to lead dusts, the subjects were divided as to degree of exposure into subgroups with slight present exposure, moderate present exposure, severe present exposure one month or less in duration, and severe exposure more than one month in duration. Table 1 shows the industrial exposure to lead other than to ethyl gasoline or tetraethyl lead for the five different groups of persons examined—A, B, C, D, and E. The fourth column, consisting of the moderate past exposures, contains the only instances of exposure in the ethyl gasoline groups or their negative control groups which might be of present clinical significance. Not only as regards time but also as regards intensity, the exposures in Group E were in most cases of an altogether different order of magnitude from those in the other groups. Groups A, B, C, and D do not differ significantly from each other in exposure to lead other than tetraethyl lead.

As regards gasoline exposure, Table 2 shows the similarity, for the purpose of this investigation, of the four groups. Similarly Table 3 shows the hours per day of exposure in the ordinary use of automobiles (Groups A and B). For the other groups, on account of the nature of their employment the length of exposure for each day was greater. In Group C, 14 were exposed to gasoline or its combustion products for 8 hours, 6 for 9 hours, and 1 for 15½ hours, daily. In Group D, 36 were esposed for 8 hours, 15 for 9 hours, 4 for 10 hours, 1 for 11 hours, and 1 for 12 hours, daily. It may here be stated that the exposure to lead dusts in Group E averaged even longer, 5 being exposed for 8 hours, 33 for 9 hours, 5 for 9½ hours, 2 for 10 hours, 4 for 11 hours, and 2 for 12 hours per day. The lengths of exposure to ethyl gasoline in Groups B and D are shown in Table 4. The number of months' exposure to lead dusts in Group E is shown in Table 5. It is obvious that the severity of exposure to ethyl gasoline is not determined entirely by the number of months of exposure or by the number of hours of exposure each day. Even in Group B, consisting of car users supplied with ethyl gasoline, the exposure (chiefly to exhaust gas) varied greatly with the type of car and the kind of driving. Driving a small car across an open country is obviously a very small exposure, but cases of carbon monoxide poisoning, even to loss of consciousness, have occurred in the groups of car users (A and B) without and with ethyl gasoline, from defective exhaust connections allowing gases to come up into the driver's compartment while out of doors. Taking all the factors of exposure into consideration, Groups B and D were each separately divided into quarters as regards severity of exposure to ethyl gasoline. These quarters (19 or 20 individuals in each for Group B and 14 or 15 indi-

viduals in each for Group D) are used for purposes of comparison in later sections of the report.

The distribution by age of the persons in the various groups is shown in Table 6. The relative excess in the higher ages shown in Groups A and D should not have a serious effect on the results of the examinations.

The large tables, Nos. 7, 8, 9, 10, and 11, give the detailed findings for the individual members of Groups A, B, C, D, and E. All the examinations, except those for stippling and the fecal examinations, were made immediately at the place of clinical examination. The urinary examinations are not listed in these tables. They yielded few or no results of value for the primary purpose of this investigation—to detect evidences of lead injury—but were of great importance to some of the persons examined. For example, two cases of marked diabetes were discovered in those who had not been aware of their condition previously. The Benedict qualitative test was used for sugar and heat and acetic acid for albumen. Twelve persons showed a slight to a large amount of sugar, 1 in Group A, 4 in Group B, 1 in Group C, 5 in Group D, and 2 in Group E. As regards albumen, which might be more indicative of lead injury, 10 showed amounts from the faintest trace to a heavy cloud; in this last person the albuminuria (in a youth of 19, otherwise in good health) was apparently connected with the ingestion of four eggs somewhat over an hour previously. Four of the persons with albuminuria were in Group A (Nos. 229, 312, 621, 961), 2 in Group B (Nos. 430, 817), 1 in Group D (No. 549), and 3 in Group E (Nos. 480, 873, 898).

Tables 12, 13, and 14 show the general condition of the persons examined, 12 giving the ratio of weight to height in the different exposure groups; Table 13, nutrition; and Table 14, the subject's statement as to the number of pounds lost from his estimated maximum weight.

Blood-pressure findings are grouped in Tables No. 15, 16, 17, 18, and 19. Table 15 gives the distribution of persons according to the systolic blood pressure in the five different exposure Groups A, B, C, D, and E; Table 16, according to deviations from the normal systolic blood pressure at each age; Table 17, according to pulse pressure when sitting; Table 18, according to pulse pressure when recumbent; and Table 19, according to the difference between the pulse pressure in these two positions.

Tables 20 and 21 show the findings in the direction of anemia, Table 20 giving the distribution according to hemoglobin percentage by Dare's instrument in the different exposure groups, and Table 21 the distribution of the erythrocyte count in these five groups. Here for the first time we see a significant difference in the persons with marked lead exposure (Group E) as compared with the other groups.

Vision was tested at a 15-foot distance on account of the size of the examining rooms. In tabulating the results of the examination for vision the test by Snellen card was used, and the result with the better eye was recorded, glasses being used if the subject wore them; this was done because any toxic diminution in acuity would tend to be bilateral and would not be corrected by refraction. In some cases the person examined did not wear glasses while at work or at the time of the examination, but did use them at other times; his recorded visual acuity was therefore lower than that of similar persons with refractive errors who had their glasses with them. Table 22 shows distribution according to vision of the persons examined in the different exposure groups. The somewhat decreased visual acuity evident in Groups A and D is correlated with the higher ages in these two groups as shown in Table 6. Group E, on the other hand, shows poorer vision than would be expected from the age grouping. At least part of this may be due to differences between this group and the others in literacy and average social status. The size of the field of vision was tested roughly by movements of the pencil in the examiner's hand at the sides of the subject. In only one instance was bilateral diminution of visual field observed—namely, No. 431 in Group D. (See Table 10.) This person probably had the heaviest exposure to gasoline of any sort, as well as to ethyl gasoline, of all those examined. He had been the gasoline filler on the night shift at the garage of the public service corporation in Dayton for 4½ months, previous to which time he drove a truck for the same corporation, using ethyl gasoline for 22 months. Between 1.30 and 4.30 a. m. each night he filled from 50 to 70 automobile tanks with ethyl gasoline. Aside from the diffusion to be expected with a 12 or 13 foot ceiling (see p. 33), there was practically no ventilation during the filling period at the time of this investigation. The cars were filled by means of a movable tank which, in turn, was refilled from time to time from a stationary tank on the main floor of the garage. Spillage repeatedly took place. There was also enough shifting of the automobiles under their own power while the filling was going on to give marked symptoms of carbon monoxide intoxication to the observer when this night filling operation was observed (December 1, 1925), and occasionally to the filler. The delivery hose was hung on a bracket on the movable tank high above the filler's head. Twelve days before this subject was examined the hose was knocked off and splashed two quarts or more of ethyl gasoline over his face and clothes. His eyes burned so that he could not see for three-quarters of an hour, but improved continually so that the vision was 15/30 at the time of the examination (October 13, 1925), and 20/24 in each eye when last seen, two months after the accident. At the time of the October examination the visual fields were slightly

but definitely contracted. There was photophobia and the pupils were slightly dilated. There was no apparent corneal inflammation or opacity. Ophthalmoscopic examination showed no abnormalities. The subject complained of headache, which, with the exception of the eye trouble, was the only symptom developing since the accident. He stated that he had had a slight tendency to constipation for two years (he had had the night filling job for four and a half months). His general health he stated was good, but he had been drowsy for four months, with twitching of the arm muscles for about a year He had a bad taste in his mouth in the morning for about three months—not metallic. For three or four months he had been dizzy when he stooped over. For about two months at times he had had sensations of pins and needles in his arms and back. He had a slight pharyngitis, temperature of 37.7, pulse, 104. His blood pressure was 144 systolic, 78 diastolic in the sitting position, 140 systolic and 80 diastolic when recumbent. His reflexes were normal, also sensation, except slightly diminished sensation of the arms to pain and touch. He had external hemorrhoids. About four weeks after the accident he returned to work as a driver, and when last seen, two months after the accident, he had for more than a month been driving a large 5-ton truck nine and one-half hours daily, without difficulty. He stated that he felt all right except for slight blurring of the eyes after reading. This man had never had a similar accident with ordinary gasoline, although numerous individuals in Group D had had similar accidents both with ethyl gasoline and with straight gasoline, with no apparent result except a temporary burning of the eyes. There is no evidence that the symptoms in this case were due to the lead content of the gasoline.

Nonquantitative data regarding the physical condition of the subjects, obtained by questioning (subjective) or by examination (objective), are given in Tables 23, 24, and 25. Tabulation is made by indicating as positive, deviations from the normal which are similar to those found in some cases of lead poisoning. For example, in Table 23, column 2, two persons (3 per cent) of Group B stated that they were ailing in some way (lowered general health), which was not classified under the more particular headings. In column 1 four persons (11 per cent) of Group A showed pallor on physical examination. Table 23 gives the general phenomena, Table 24 those of the digestive system, and Table 25 the nervous phenomena. Perhaps the most striking fact shown in these tables is the larger proportionate number of digestive and nervous disturbances in Group E, those exposed to a known definite lead hazard, than in the other groups.

Even more striking than these tables is the consideration of the individuals taken one by one. Aside from case 431 discussed above,

there are no persons in Groups A, B, C, and D in whom the clinical findings described in this section of the report are at all suggestive or significant of lead intoxication. On the other hand, Group E presents seven definite cases of lead poisoning made out independently of the industrial history, by clinical examination alone apart from stippling or chemical examination of the feces. The clinical examination was, as indicated in Section I of this report, especially directed to detect lead poisoning. These cases are Nos. 15, 150, 187, 276, 732, 813, and 873. (See the large Table 11.) Seven other cases of slight lead poisoning were apparent by the same methods—Nos. 221, 307, 324, 360, 370, 656, and 764. One other individual, No. 253, gave evidence of former lead poisoning, though no such intoxication could be made out at the time of examination. As may be seen in the large tables, as well as in Tables 20 and 21, a certain degree of anemia was part of the picture in some cases of Group E. Examination of the feces for intestinal parasites which might be responsible for the anemia was made in all cases where fecal specimens were available, and was negative.

Sleeplessness, generally considered one of the most significant indices of poison by lead tetraethyl, was inquired into by double questioning, as is seen on schedule card 2 in Section I of this report. Questions as to the character and amount of sleep were asked at the beginning of the examination and again later when the subject's attention was being directed to other nervous and mental phenomena. Seven in Group A, 2 in Group B, 1 in Group C, and 3 in Group D deviated more or less from the general rule of frank statements that their sleep was restful and that there was absolutely no insomnia. The deviations in these groups were only slight and usually some reason was given, such as "No insomnia except when gas on stomach; sleep good and restful"; "Restful at present, not during summer with warm weather; no insomnia"; "Sleep fair; nose stopped occasionally, rheumatism in right shoulder, no insomnia"; "Sleep not very restful; some insomnia last two years since marriage due to increased responsibility, he thinks." The data elicited under these heads in Group E (seven cases) were more positive as regards insomnia or disturbances of sleep and usually were correlated with the degree of lead hazard. Six out of these seven were among the 14 cases of lead poisoning.

In planning this investigation special emphasis was laid on three methods of examination which it was thought would possibly yield more definite quantitative data regarding slight deviations from the normal and which would be more clearly indicative, and at the same time freer from subjective errors, than other methods. These were, first, the determination of the amount of lead in the feces, which would show lead exposure or absorption; second, quantitative exam-

ination of the red-blood cells for stippling, which in the absence of other causes would show lead absorption; and third, measurement of the strength of the extensor muscles in the forearm, which would be indicative of lead neuritis. It may be stated at once that this last method yielded practically no information of positive value for the present investigation. The method and results, however, are given here as negative evidence and in order that comparison may be made with other more marked instances of lead poisoning.

The apparatus for muscle testing consisted of a hinged platform for the hand with the axis of rotation the same as that of the wrist. Fixed to each side of this rotating platform was a grooved solid wooden pulley with a radius of 6 inches but complete for only about one-fourth of a circle, from a point flush with the movable platform toward the finger end to a little past vertical above the hinge. The center of these pulleys was not at the table level but 1 inch above, at the axis of rotation of the wrist. Cords were fastened at the upper end of the pulleys passing over the curved grooves to a yoke by which they were both attached to a recording dynamometer (a spring balance with adjustable index registering the greatest maximum pull). This dynamometer was supported on rollers, and attached to the other end was a cord which was pulled either by the examiner's hand, or, for the stronger muscles, by a pedal attachment after passing over a pulley. The hinged platform was moved by the subject by means of a broad wooden nest for the whole hand or a narrow metal one for the middle and ring fingers. These two nests were detachable and could be adjusted for different lengths of fingers. Along each horizontal edge of the hinged platform was a brass index by means of which the angle made by the platform could be read off on a scale attached diagonally on either side of the base.

In using the instrument the subject placed his hand in the nest with his wrist joint at the axis of rotation, palm down for measuring extensors and palm up for measuring flexor strength. He then raised the platform until it made an angle of 25 degrees with the horizontal, at which point the pull was gradually exerted by the examiner while the subject was told to keep the hand in this position by resisting the pull. When the strength of the subject's muscles was overcome by the examiner's pull to such an extent that the index fell below the 22° 30′ mark, the examiner's pull was released and the reading in pounds, automatically registered by the sliding index of the dynamometer, was taken. Three consecutive measurements were made of each muscle group. Figures 1, 2, and 3 illustrate the instrument. Usually a wooden bar was adjusted just above the wrist by means of leather straps to keep the axis of rotation of the wrist joint at the same level throughout the test. In three of the cases of lead poisoning, Nos. 187, 307, and 732, definite neuritic weakness was observed

Fig. 1.—Apparatus for testing strength of flexor and extensor muscles in the forearm. The subject to be tested sits in the chair, while the physician uses the pedal attachment in testing the strong flexor muscles of the wrist. The larger registering dynamometer for testing these strong muscles is shown in place on the roller carriage; the smaller dynamometer, for testing the weaker extensor muscles and the finger muscles, is placed below. The nest for the fingers, also not in use, is shown to the left of the smaller dynamometer. The adjustable wooden bar for keeping the wrist down at the same level during flexion and extension is at the extreme left of the apparatus

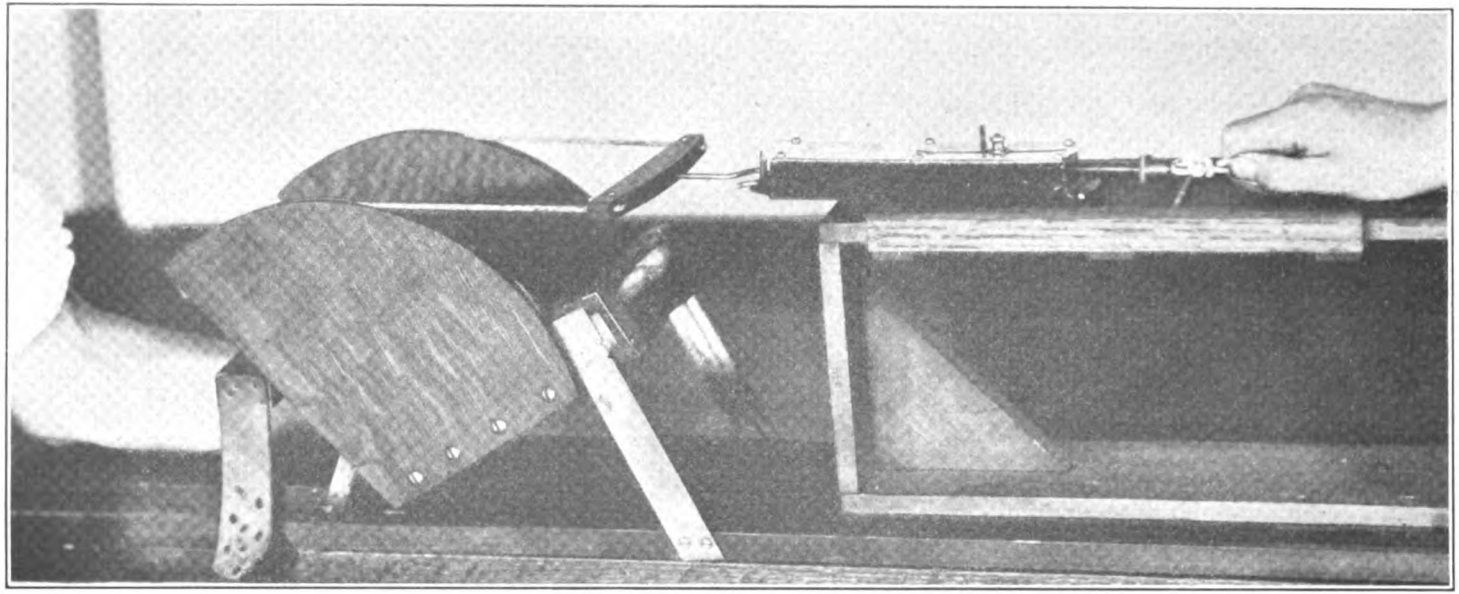

Fig. 2.—Apparatus for testing strength of flexor and extensor muscles in the forearm in use for testing the extensors of the left wrist. The pull is being exerted by the operator on the spring of the smaller recording dynamometer which rests on the roller carriage, while the hand of the subject being tested, palm downward, is in the nest for the whole hand with the axis of rotation of the wrist kept in line with the axis of the wooden pulleys; the subject endeavors to prevent the index on the tilting platform from falling below the point marked 22° 30′ on the brass scale

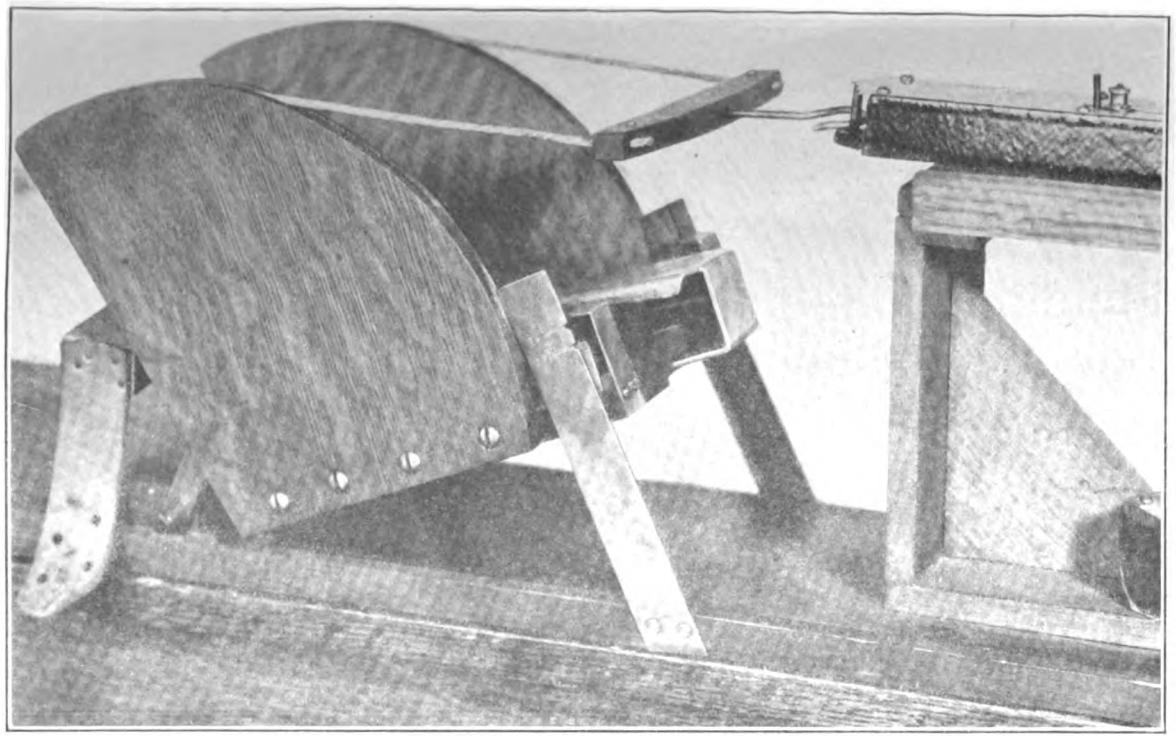

Fig. 3.—Apparatus for testing strength of flexor and extensor muscles in the forearm. Apparatus in greater detail with the nest for testing extensors and flexors of fingers in place. The index of the hinged platform is almost exactly at the 22° 30′ mark of the diagonal brass scale. When the pull by the operator overcomes the subject's resistance to such an extent that the index passes below this mark the reading is taken

by the use of this instrument, which could not be detected by ordinary manual estimation of wrist strength. It is evident, however, that in only a small proportion of the cases of early lead poisoning is there a demonstrable weakness of the extensors in the forearm. In order to ascertain whether the lesser degrees of lead palsy were specifically confined to these extensor groups or were more easily shown there because of the natural weakness of these muscles, the flexors were also tested. In an attempt to secure data on Edinger's theory of fatigue paralysis and the preponderance of right-sided paralysis over left-sided in the lead palsy of right-handed people, comparison of the two sides were made. For tabulation the median figures were taken as more indicative than averages when there were three to six measurements to be grouped. Tables Nos. 26, 27, 28, 29, 30, and 31 show the distribution of various indices of the strength of these muscles, namely, the wrist and finger-extensor groups. Table 26 shows the medians of all the ratios in the different groups. In Table 27 the ratio of the median of the six measurements of the strength of the wrist extensors of each individual (three trials of the right hand and three of the left) to his weight is given as a distribution table. It was felt that the mere strength measurements without reference to the size of the individual would give erroneous indices. At the same time in studying the individual cases it was the actual value of this median rather than the ratio of the median strength of pull to the weight which gave indication of significant wrist weakness in Group E. As shown in Table 27, negative control Group A is as weak according to strength-weight ratio as is Group E. Table 28 shows in the same way the distribution of ratios of the strength of finger extensors to weight in the different exposure groups. Table 29 shows the distribution according to ratio of strength of wrist extensors to that of wrist flexors; Table 30, according to ratio of the strength of finger extensors to that of finger flexors; Table 31, according to strength of right wrist extensors to that of left wrist extensors; Table 32, according to ratio of the strength of right-finger extensors to the strength of left-finger extensors.

SECTION III

STIPPLED RED CELLS

Examination for stippling took place at the Hygienic Laboratory of the United States Public Health Service at Washington, D. C. It involved about 600 hours of microscopic work on the part of highly-trained laboratory workers expert in the use of the microscope. Four smears nearly covering the surface of the slides were made from each subject examined. These were fairly uniform in thickness, the red cells being close together but not overlapping in

more than half of the cells. A modified Sussmann-Weindel toluidine blue stain was used as follows:

Toluidine blue [1]	grams	5. 0
Borax	do	0. 5
Loeffler's methylene blue	cubic centimeters	50
Distilled water	do	1, 000
1 per cent aqueous solution Eosin (yellowish)	do	7. 5

The specimens were fixed in 96 per cent alcohol and stained 20 minutes in the above solution. The addition of the eosin aided greatly in retaining the focus and in distinguishing overlying particles from true stippling. Different samples of dry toluidine blue were found to vary greatly in staining properties. A preliminary comparison of different stains gave the following result with slides from a case of lead poisoning with considerable stippling:

	Stippled cells per 100,000
Toluidine blue	600
Manson's borax methylene blue	750
Wright's stain	800
Unna's methylene blue	1, 020
Toluidine blue with Loeffler's methylene blue	1, 050

It was originally planned to stain half the films from each case with the modified toluidine blue, as given above, and half with Wright's stain. Consequently some films from all cases were stained with toluidine blue, and with remarkably uniform results. In a number of instances it was necessary to stain a second or even a third film from the same case, but on account of unsatisfactory films rather than unsatisfactory staining. After all the slides had been examined and classified as to the degree of stippling present it was thought wise to try again the Wright stain to determine whether anything of importance could be gained by staining films from all cases by this method. It had already been shown that with Wright's stain basophilic stippling is best seen in films which have a distinctly bluish tone. This was most readily obtained by diluting Wright's stain on the slide with 1 per cent sodium bicarbonate solution, staining one minute, and washing with neutral distilled water. As a preliminary procedure a number of unstained films from cases known to show definite basophilic stippling were stained, one-half of the slide with Wright and one-half with modified toluidine blue. These films were submitted to several members of the staff for examination, and all agreed on the superiority of the modified toluidine blue for the demonstration of basophilic stippling. The slides were classified on the basis of the stippling examination into nine groups:

[1] Dissolve the borax in the distilled water, with heat if necessary, then the toluidine blue, and add the methylene blue solution. Filter and add the eosin solution just before using.

1. Those unsatisfactory for examination because of poor film or poor stain (a considerable number of slides were at first placed in this class, but by staining the reserved slides from these cases all were finally classified more definitely).
2. Negative.
3. One to three cells with very fine stippling per 100,000. (Usually these cells were basophilic and often the granules were so fine that some workers could not see them.)
4. Four or more cells with very fine granules per 100,000. (If any cells with definite granules were found in a slide, even though cells with very fine granules were present, the slide was not grouped under class 3 or 4 but in a higher group.)
5. Definitely stippled cells, fewer than 3 per 100,000.
6. Three to 6 definitely stippled cells per 100,000.
7. Seven to 20 definitely stippled cells per 100,000.
8. Twenty-one to 100 definitely stippled cells per 100,000.
9. Over 100 definitely stippled cells per 100,000.

Reserved films from 14 cases which had fallen under Group 8 by the toluidine blue stain were stained by the alkalinized Wright method and submitted to six members of the staff for examination, with the result that 2 were classified under Group 9; 8, under Group 8; 3 under Group 2; and 1, under Group 1. Next, separate films stained by both methods from several cases classified under Group 8 by the toluidine blue method were submitted to two of the most expert members of the staff for comparative examination. In all cases more stippled cells were found in the toluidine blue films in a given length of time. All members of the staff who had examined films by both stains agreed that the toluidine blue stain was the more satisfactory for the demonstration of the basophilic stippling. The final results as shown in the tabulation are therefore based entirely on the toluidine blue stain.

The examination was chiefly on a time basis. By means of vernier readings on mechanical stages, measurements of fields, counts of number of cells per field, and counts of number of fields examined in a given time, the findings were reduced to figures expressing numbers of stippled cells per 100,000. In this estimation it was considered that in each field only the central zone, one-third the width of the entire field, was as a rule thoroughly examined.

The staff which examined and checked the slides had no information concerning the identity of the persons or groups from which the films were obtained. No slide was pronounced negative until after 90 minutes of examination, care being taken by use of the mechanical stage to prevent the examination of the same field more

than once. Less than 90 minutes' examination was made only when six or more stippled cells were found in less than that time.

Every slide found negative was reexamined for an average period of 10 minutes by a medical officer recognized as an expert in laboratory procedures involving the use of a microscope. When a positive cell was found during this period an additional 10 to 30 minutes were spent in examining the slide. Slides found positive on the original examination were confirmed at the time by one of the above medical officers, practically every stippled cell being carefully checked. Efficiency of the examiners was shown by the fact that this reexamination and checking changed the classification of very few slides, and in such instances, almost without exception, by only one class. The final classification by cases is as follows:

1. Unsatisfactory, none
2. Negative, 133.
3. One to 3 cells with very fine granules per 100,000, 15.
4. Four or more cells with very fine granules per 100,000, 3
5. Definite stippling but fewer than 3 stippled cells per 100,000, 35.
6. Three to 6 stippled cells per 100,000, 16.
7. Seven to 20 stippled cells per 100,000, 14.
8. Twenty-one to 100 stippled cells per 100,000, 17.
9. More than 100 stippled cells per 100,000, 19.

For practical purposes classes 2, 3, and 4 might be taken as negative, although the granulation recorded under Groups 3 and 4 is evidently in the direction of true stippling. The examination was sufficiently prolonged, however, to carry over into Groups 5 to 9, slides which showed any stippling except an amount which might be called normal. Table 33 gives the amount of stippling in each exposure group, namely:

A. Users of automobiles without ethyl gasoline.
B. Users of automobiles with ethyl gasoline
C. Garage workers and gasoline handlers not in contact with ethyl gasoline or its combustion products.
D. Garage workers and gasoline handlers in contact with ethyl gasoline and its combustion products.
E. Persons exposed to definite lead-dust hazard.

The examination, the results of which are recorded in this table, gives by far the clearest differentiation between exposure groups of any of the examinations thus far covered in this report. It is seen at once that Group E is entirely different from the other groups. Table 34 shows the distribution of stippling in Group E according to the different amounts of exposure. Stippling to a relatively high degree (21 to 100 stippled cells per 100,000) was shown in persons whose exposure to this hazard had been very short—as short as

two and one-half days. Stippling was also shown by some individuals whose exposure to the lead dusts seemed to have been extremely slight. It is noteworthy that even with this obviously delicate method of detecting lead exposure and absorption, Group B shows no greater stippling than Group A. This lack of stippling from the ethyl gasoline hazard in Group B is also shown by Table 35, in which this group is divided into four quarters according to the amount of exposure—the number of hours of exposure each day, the number of months' exposure, and the degree of exposure all being taken into consideration. Subgroup 1 in this table is the quarter with least exposure, Subgroup 2 the next, Subgroup 3 the next; Subgroup 4 is the quarter with the highest exposure. It is clear that there is no increase in stippling with increased exposure in this group. Group C, the garage workers and gasoline handlers exposed to gasoline and its combustion products but not to ethyl gasoline, shows what might possibly be a significant increase in stippling over Groups A and B. This group is too small for conclusions to be drawn in that direction. Group D, garage workers and gasoline handlers exposed to ethyl gasoline and its combustion products, also shows some increase in stippling but of a magnitude altogether different than that shown by Group E. The significance of the increased stippling shown by Group D is questionable in view of its rather uniform distribution when this group is divided into quarters according to degree of exposure, as shown in Table 36.

Many of the individuals of Group D acknowledged that they had repeatedly spilled ethyl gasoline over themselves. Some said that of necessity all handlers of gasoline (filling-station attendants and tank-truck drivers) are thus exposed. Nineteen had also spilled ethyl fluid, the concentrated 60 per cent mixture of lead tetraethyl, over themselves during the period when the addition of tetraethyl lead to the gasoline was made at the individual filling stations. The distribution of the stippling in Group D according to history of such spillage is shown in Table 37.

SECTION IV

CHEMICAL EXAMINATION OF FECES FOR LEAD, INCLUDING METHODS USED FOR ALL CHEMICAL ANALYSES MADE DURING THE INVESTIGATION

The cooperation of the subjects examined in giving specimens of feces was remarkable in that it was purely voluntary. Of the 252 examined, 200 brought back fecal specimens. Of the 200 specimens, 2 were lost, but an additional specimen was secured from a man who was not one of the 252 men examined but who, subsequent to the examination, took the place of subject 431 mentioned on page 15 of this report. Thus, the results on 199 specimens are reported.

The analyses were made at the Hygienic Laboratory, Washington, D. C. It was originally planned that check examinations of part of each specimen or of some of the specimens would be made at two other laboratories equipped for this fecal lead determination. The amounts of ash and lead found, however, were so small that such splitting of the samples would have tended to minimize the accuracy of the result on account of the large proportionate possible error when specimens containing small amounts of lead were tested.

The specimens were collected in preserve jars which were prepared at the Hygienic Laboratory. "Atlas E–Z Seal" flint-glass preserve jars with glass covers were carefully cleaned, provided with clean rubber gaskets which had been covered with a mixture of paraffin and petrolatum, and shipped to the places of clinical examination. Almost complete digestion of samples of this glassware by hydrofluoric acid yielded solutions containing no lead, and it was therefore concluded that the lead content of the glass was insignificant. To each sample of feces 5 cubic centimeters of formalin were added before shipment to the Hygienic Laboratory. This formalin had been examined in duplicates of 100 cubic centimeters and yielded no evidence whatever of lead. Five cubic centimeter portions of this same stock of formalin were included in every blank analysis. The jars containing the samples of feces were shipped in locked boxes and were stored in a locked room until subjected to analysis.

The method of analysis used was a modified Fairhall method. The entire sample of feces was transferred to a tared dish of Coors porcelain, weighed, capped with filter paper, dried in a hot-air oven at 120° to 150° C. for 10 to 12 hours and then ashed, after removal of the caps, at 500°–600° C. In the ashing of the first few samples in the regular electric furnace the temperature probably rose slightly above the 600° specified, since it was discovered by the furnace color that the automatic electric control was not correctly calibrated. The control was then adjusted to maintain what was subsequently proved to be a temperature of 550° ± 20° C. The greater number of ashings were made in a specially constructed electric furnace built with fired, natural "Sil-o-Cel" brick and with exposed coils of chromel A wire. The construction was such as to place the dishes centrally with respect to radiation. Thermocouples calibrated by the melting points of Roberts' salt mixtures were placed near the roof of each compartment where they would receive the most central radiation and be in the upper stratum of hot air. Cold junctions were placed in ice. Potentiometric readings were made frequently and the heating current was controlled by a rheostat so that the maximum central temperature of the furnace would remain well below the 600° C. specified. The actual temperatures maintained in this special furnace were generally 550° ± 20° C.

When cool the ash was moistened with distilled water, treated with 10 to 20 cubic centimeters of 1:1 hydrochloric acid solution, and warmed to facilitate solution. The resulting suspension was filtered through a No. 40 Whatman 11-centimeter paper into a 250-cubic centimeter Phillips beaker, and the residue was washed, first with hot 10 per cent hydrochloric acid solution and then with hot water. The paper and residue were transferred to the original porcelain dish, dried, and again ashed as described above, until free from carbon. The second ash was moistened with 10 cubic centimeters water, treated with 5 cubic centimeters of 10 per cent tartaric acid in 1:1 hydrochloric acid, warmed, filtered, and washed as before. At this point care was taken to avoid gumming or charring the tartaric acid. The filtrate, obtained as in the first instance, was mixed with that from the first ash. Whenever there was a residue after the second ashing, it was discarded.

The combined filtrates were diluted to 500 cubic centimeters with distilled water and neutralized with 25 per cent sodium hydrate solution until yellow to methyl orange. The reaction was then adjusted with 1:2 hydrochloric acid until the color of the indicator was a faint reddish-orange. The solution was shaken occasionally for half an hour, readjusted to a pink, and then sulphided. Hydrogen sulphide, from a Kipp generator in the earliest work and from a tank of liquid hydrogen sulphide in the later work, was passed through a series of scrubbing towers and wash bottles and delivered from a manifold, the glass outlets of which were well below the surfaces of the solutions to be sulphided. These outlets pierced clean filter papers with which each Erlenmeyer flask was capped. Placed well above each cap, to avoid eddy currents which might cause dust deposits but sufficiently close to remove escaping gas, were 1.5-inch holes in a paraffined wooden beam, and through these holes a stream of air to the hood flue was maintained. A moderate stream of hydrogen sulphide was passed through the solution for one hour; the solution was thoroughly shaken and gassed again for about 10 minutes. The flask was then capped and allowed to stand overnight.

The precipitate was recovered by filtration through a No. 40 Whatman 11-centimeter paper and was washed with freshly prepared hydrogen sulphide water containing 0.1 per cent hydrochloric acid. This precipitate was transferred to the original sulphiding flask by washing it from the paper with hot water, followed by 15 cubic centimeters of 1:1 hydrochloric acid solution. If this failed to clean the paper it was treated with 10 drops of 1:1 nitric acid, followed by hot water. In cases where this was not necessary the nitric acid was always added directly to the flask. Hot water was used for a final thorough washing.

The suspension was then boiled to dissolve sulphides and evaporated by boiling to a volume of about 3 cubic centimeters. This was diluted to 400 cubic centimeters with distilled water, neutralized with 25 per cent sodium hydrate solution till yellow to methyl red and the reaction readjusted with hydrochloric acid till faintly pink. One cubic centimeter of 1:2 hydrochloric acid was then added as an excess. The sulphiding was then repeated as in the first instance.

The sulphide was collected on a No. 40 Whatman 11-centimeter paper and washed with freshly prepared hydrogen sulphide water containing 0.1 per cent hydrochloric acid. It was then transferred to a 250-cubic centimeter Phillips beaker by a stream of hot water, followed by 10 to 15 cubic centimeters of 1:1 hydrochloric acid solution. The suspension and paper were treated as before, and the solution when diluted to 200 cubic centimeters was neutralized with 25 per cent sodium hydrate solution until yellow to thymol blue. With 1:2 hydrochloric acid the color was brought back to a faint pink and then the solution was sulphided as before.

The precipitate was collected on a No. 40 Whatman 9-centimeter paper and washed very thoroughly with freshly prepared hydrogen sulphide water containing 0.1 per cent hydrochloric acid. The precipitate was then dissolved with 10 cubic centimeters hot 1:1 nitric acid, the solution running through the paper into a precipitating flask. A hole was punched in the paper and the residue of sulphur washed into the flask. The solution was then evaporated to a volume of 2 to 3 cubic centimeters to coagulate sulphur. This was filtered off into a 125-cubic centimeter Phillips beaker and the paper and flask were carefully washed. The volume of solution was now about 50 cubic centimeters. This was neutralized with 25 per cent sodium hydrate solution (free from aluminium and iron) until thymol blue, added as an aqueous solution, turned blue. This color was discharged with a 5 per cent solution of acetic acid and then an excess of 3 cubic centimeters of this acid was added. The solution was heated to boiling and an excess, about 1 cubic centimeter, of a 1 per cent solution of potassium chromate was added. The Phillips beaker, covered with a watchglass, was warmed on a hot plate (not boiled), put in a warm place, and allowed to stand overnight.

The lead chromate was then collected on a No. 40 Whatman 7-centimeter paper, and the beaker and paper were washed very thoroughly with hot water to remove all possible traces of soluble chromate. The precipitate was dissolved and washed through the paper into the beaker in which the chromate precipitation was made with 10 cubic centimeters cold 1:2 hydrochloric acid solution, followed immediately with cold water to the extent of about 50 cubic centimeters. Care was taken that all the residue, including possible

lead chloride, was removed. The sides of the beaker containing the chromate were washed with 10 cubic centimeters of 1:2 hydrochloric acid solution.

There were then added a potassium iodide solution and 1 cubic centimeter of 0.5 per cent starch solution. The potassium iodide added was 1 cubic centimeter of a 1 per cent solution in most cases, 2 or 3 cubic centimeters in exceptional cases, and an excess in all cases. The liberated iodine was titrated immediately with a 0.005 normal solution of sodium thiosulphate freshly prepared from a standardized 0.1 normal solution. The thiosulphate was delivered from a burette etched at intervals of 0.05 cubic centimeters and capable of being read to 0.01 cubic centimeter. The factor 0.3452 was used to convert cubic centimeters of 0.005 normal thiosulphate to milligrams of lead.

Analyses of sweepings.—The sample was digested with aqua regia. The supernatant solution was diluted with hot distilled water and decanted. The digestion and decantation were then repeated. Finally the washed residue was dried, ashed, and digested in a platinum dish with a solution of hydrofluoric acid which was allowed to evaporate slowly. The dry residue was treated with a concentrated solution of hydrochloric acid, evaporated to dryness, and extracted with 1:1 hydrochloric acid solution. This extract was combined with the original. The combined filtrates were diluted to 500 cubic centimeters, neutralized, subjected to three sulphidings, etc., as for feces. (The results are noted in Section V, pp. 31–37 and 97–100.)

Determination of lead in air-dust samples collected by the impinger method (collection described in Section V.)—Fifty cubic centimeters of 1:1 nitric acid solution were added to the sample and the mixture was evaporated to dryness on a hot plate. The residue was digested with 5 cubic centimeters of 1:1 hydrochloric acid solution and again evaporated to dryness. This was repeated. Then there were added 5 cubic centimeters of a 1:1 hydrochloric acid solution. The mixture was evaporated to a volume of about 2 cubic centimeters and diluted to 100 cubic centimeters with distilled water. In cases where the original residue was small the dilution at this point was halved. The solution was neutralized with 25 per cent sodium hydrate solution until yellow to thymol blue and the reaction then was readjusted to a faint pink by means of hydrochloric acid solution. The solution was then sulphided. In cases where no appreciable precipitate was obtained there were added two drops of 2 per cent copper acetate solution and the sulphiding was continued one hour. The sulphided solution was allowed to stand overnight and then filtered. The precipitate was washed, dissolved with 1:1 nitric acid solution, and treated from then on according to the procedure given above for fecal analysis.

Determination of lead in precipitation tubes. (See Section V.)—The tubes were washed twice with 5 cubic centimeter portions of "C. P." acetone, twice with 10 cubic centimeter portions of 1:2 nitric acid solution, and finally with 10 cubic centimeters distilled water. The combined liquids were evaporated to dryness, treated with concentrated nitric acid, and 0.5 grams potassium chlorate, and then heated gently. The mixture was again evaporated to dryness. The residue was digested with 25 cubic centimeters distilled water and 5 cubic centimeters of 1:1 hydrochloric acid solution. This solution was treated as described above for impinger samples.

Determination of lead in charcoal. (See Section V.)—The charcoal samples were treated with cold nitric acid for 24 hours. This nitric acid extract was evaporated to dryness and analyzed according to the method previously described. The residue from the charcoal, after extraction, was ashed and treated in the same manner as the samples of feces. These two analyses were joined at the end. In all but the two samples showing the highest lead content all the lead was taken out by the first extraction with nitric acid.

Determination of lead in gasoline. (See Section V.)—The sample was well shaken and 25 cubic centimeters, as measured from a water-calibrated pipette, were withdrawn and placed in a Kjeldahl digestion flask to which 25 cubic centimeters absolute ethanol had been added. Small portions of bromine were then added while the flask was vigorously shaken, until a red color persisted. The mixture was then allowed to stand overnight.

It was next evaporated over a water bath to 10 to 15 cubic centimeters. Twenty-five cubic centimeters of concentrated nitric acid were added and the mixture evaporated to dryness on a water bath. An additional 25 cubic centimeters concentrated nitric acid and 2 grams potassium chlorate were added and the mixture heated gently over a free flame. In some instances this did not complete the oxidation of organic material and in such a case the digestion with nitric acid and chlorate was repeated.

When the organic matter was completely oxidized the solution was evaporated to dryness. The residue was then treated with 50 cubic centimeters distilled water and 5 cubic centimeters of 1:1 hydrochloric acid and warmed on a water bath until solution was complete. The solution was then transferred from the Kjeldahl flask to a 500 cubic centimeter Erlenmeyer flask, made up to a volume of 200 cubic centimeters with distilled water, neutralized with 25 per cent sodium hydrate solution (free from aluminium and iron) until yellow to thymol blue, and then made faintly pink with 1:1 hydrochloric acid solution. The procedure from this point followed the method used for feces as described above.

For some of the later samples the first part of this method was varied as follows: 50 cubic centimeters of the original sample was

treated in a clear, dry 500 cubic centimeter Erlenmeyer flask with 10 cubic centimeters of a 30 per cent (by volume) solution of bromine in carbon tetrachloride, the flask being kept in ice water to prevent heating. The separated solid was filtered through a dry prepared Gooch crucible, and the crucible and flask were washed several times with anhydrous petroleum ether. The crucible was then set in a 250 cubic centimeter beaker, 10 cubic centimeters of concentrated nitric acid were added, and heat was applied till bromine fumes no longer came off. After the contents of the crucible were carefully emptied into the beaker with the aid of a stirring rod, the crucible was washed well with distilled water. The liquid was brought to a boil and filtered on another Gooch crucible, the asbestos being washed well with hot water. From this point the Fairhall method, as given above for fecal examinations, was employed.

Method of water analysis.—Four liters were evaporated till nearly dry in platinum dishes on a hot plate, shielded by a glass cage to protect from dust. Evaporation to dryness was completed over a water bath. The residue was treated for lead as in the case of analysis of the solution from the ashed feces.

The filtrate from the first sulphiding was boiled till free from hydrogen sulphide. Nitric acid was then added and after boiling the aluminium and iron were precipitated with ammonia. From then on the procedures of "Standard Methods of Water Analysis" were followed for the determination of calcium and magnesium.

General.—For the analytical work, cleaned rooms and hoods painted with lead-free oil paint or with asphalt were used. Putty and similar materials near operations were coated with asphalt. All operations of other investigations, especially precipitations in which lead acetate is used, were kept away from the space occupied by the analysts. Also the washing of glassware was supervised, not alone to insure clean apparatus but to prevent its being mixed with that used in other laboratories. All solutions, when not under operation, were covered with bell jars. Tested reagents were isolated. All glassware introduced to the lead analyses was new Pyrex ware. Particular care was maintained in the labeling of the successive stages of a given analysis.

Reagents were found or were prepared which were so far free from appreciable traces of lead that throughout the analytical work here reported blank controls, made separately or with each group of analyses, yielded almost uniformly zero lead content.

When this was accomplished, the analysts familiarized themselves with the application of the method to "normal" feces collected from persons about the laboratory. The results are shown in Table 38.

To determine the degree of correspondence between the results of different analysts, six samples of feces were divided at the point of

analysis where the ash is put into solution, and the aliquot portions analyzed by two or three of the chemists separately. The actual results obtained in the analyses of samples of feces divided between the analysts are as follows. In one instance (No. 223) analysts A, B, and C found 0.16, 0.24, and 0.21 milligrams of lead, respectively, in the three portions. In No. 810 analysts A and B found 0.31 and 0.32, respectively. In No. 99 analysts A, B, and C found 0.11, 0.14, and 0.13, respectively. In No. 671 analysts A, B, and C found 0.27, 0.24, and 0.18, respectively. In No. 523 analysts A and B found 0.41 and 0.39, respectively. In No. 676 analysts A and B found 0.18 and 0.13, respectively. The variations from the mean result in each case were from -0.05 to $+0.04$ milligram with a median (disregarding signs) of 0.01 milligram.

More analyses by this procedure were not made because the analysis of divided samples showing such small amounts would give a greater proportionate degree of error than treatment of each sample as a whole; because of the limited time remaining between making ready to handle large numbers of analyses and the time set for their completion; and because it had become clear in the earlier control work with slightly contaminated reagents and with the Fairhall method in its unmodified form that the analysts were obtaining reasonably good checks both in controls with known amounts of lead and with split samples of unknowns so long as the lead content remained above 0.2 milligram, though serious errors appeared with contents of lead below this value. While these difficulties with samples of low lead content were largely eliminated when pure reagents were finally obtained (as they were before the samples from the subjects examined were collected), it appeared that the final results would be more reliable, for statistical treatment at least, if each entire sample was analyzed as one.

For comparing different groups as to feces analyses, an average error of about ± 0.05 milligram may be expected in the amounts of lead found, and no important conclusions should be drawn from an individual case unless an error of ± 0.1 milligram be considered as possible.

The results in each case are recorded at the bottom of the large Tables Nos. 7, 8, 9, 10, and 11 in terms of total milligrams of lead found in the sample, of milligrams of lead per gram of sample, and of milligrams of lead per gram of ash. The results are distributed according to exposure groups and subgroups in Tables 39, 40, and 41. Table No. 39 shows the milligrams of lead per gram of ash in the different exposure groups and subgroups. Table No. 40 shows the total milligrams of lead per sample in these groups, and Table No. 41 shows the milligrams of lead per gram of sample before drying of ash in the same groups. It is believed that the amount of lead per

gram of ash is probably a more equable index for comparison between different cases than the other methods of stating results. This ratio is shown in Table 39. Table 42 is inserted to show what effect or lack of effect on distribution among the exposure groups would be caused by considering in every case the mentioned error of 0.05 milligram in total lead found in sample, as a negative error.

The same definite difference between Group E and the other groups is shown in these tables as in the stippling Table No. 33, pages 86 and 22, of this report. There is also some increase but of an entirely different order of magnitude in Group D and possibly in Group C over the amounts found in Groups A and B.

SECTION V

ATMOSPHERIC AND DUST STUDIES

In view of the practically negative results from the clinical examination of men exposed to ethyl gasoline, and the surprising uniformity with which lead was detected in the feces of presumably normal persons, it becomes of interest to ascertain the degree of contamination in the surroundings of both these sets of men. Therefore a few estimations of carbon monoxide or lead content were made of various materials which were collected at their work places.

The carbon-monoxide content of the air at the places of exposure was estimated by the Sayers-Yant pyrogallic-tannic acid method. Samples of the gasolines used were taken and the lead content determined. Similar estimation was made of a small sample of kerosene which had been used for cleaning carburetors by the spray method in the Cincinnati test garage. Test sweepings from the various places of work were analyzed for lead. The amount of lead as particulate matter in the air of the garages studied was estimated by the Greenburg-Smith impinger [1] and by the Drinker portable precipitator.[2] An apparatus was also devised which was intended to give some idea of the amount of lead as vapor in the atmosphere. This apparatus consisted of a Hancock ejector, a flow meter, and a glass sampling tube containing activated charcoal. The ejector when used with the compressed air available in the garages created sufficient suction to pull the air from the room through a cylindrical glass tube about 2½ inches in diameter and 8 inches long, tapering to the bottom to one-half inch in diameter, and filled with activated coconut-shell charcoal. This charcoal was supported in the tube by a finely meshed copper screen. The air passed from the charcoal through the flow meter at the rate of 15 meters per minute. It was felt that any evaporated lead tetraethyl would be absorbed by the charcoal.

[1] Public Health Bulletin No. 144, January, 1925, p. 66.
[2] Jour. Industrial Hygiene, VII, No. 6, June, 1925, p. 268.

After sufficient air had been aspirated through the charcoal the contents of the tube were transferred to a quart preserve jar, such as was used for the collection of the specimens of feces, and the tube refilled for the next test with previously dried activated charcoal. At each of the places studied a sample of tap water such as is used for drinking was also taken for analysis for lead, calcium, and magnesium content. The chemical analyses, except the carbon-monoxide determinations, were all done at the Hygienic Laboratory, and a description of the methods used is contained in the preceding section of this report.

The building housing the municipal garage, containing the cars used by most of the subjects in Group A, is a two-story concrete structure, with the garage located on the ground floor. The second floor is used as a carpenter shop and storeroom. Adjoining this building are the repair shop and offices, which are housed in an old-fashioned brick structure. The garage proper is rather dimly illuminated. However, it is kept very clean, swept daily, and is seldom crowded, no more than 30 cars being stored at any one time. Table 43 shows the number and make of cars entering and leaving the garage during the day. This room has 32 rather small windows, the window space totaling only 184 square feet, giving a window to floor space ratio of only 0.02. The ceiling height is 13 feet 6 inches, and the volume of the garage 102,870 cubic feet. There are three outside doors to this garage, but only one of these is ever used. This door and a pipe of 30 inches diameter connected to the ventilator on the roof, are the only means of ventilation. The windows were observed to be closed at all times. The ventilator pipe seemed to give a much more satisfactory condition of air than was observed in the test garage in this city. At no time during the day or night are conditions in this garage congested. Not more than six cars were observed to enter at any one time, and that number only rarely. Cars were brought in and taken out between 6.30 and 8 a. m. and from 3.30 to 6 p. m. As each car enters it is filled with gasoline and oil, if it requires any, and such cars as are not filled at this time at the stationary tank are filled later by the watchman using a gasoline can. Filling is usually completed by 6 p. m. No work of any kind is done after that hour. No repair or testing of cars is ever done in the garage, such work being conducted in the repair shop in the adjoining building during the day. Table 44 gives the results of 14 determinations of carbon monoxide in the air at the Dayton municipal garage. At no time did the carbon-monoxide content of this room reach 0.04 per cent. A sample of the gasoline used in this garage gave negative results for lead. Dust sweepings taken in the evening from the floor and a table, nine hours since the room had been swept, gave 1.65 milligrams of lead per gram of sample. On another occasion sweepings from around the pillars of the garage gave 2.08 milligrams of

lead per gram of sample. On a third occasion sweepings from the floor and benches gave 0.82 milligram of lead per gram of sample. Dust collected from 150 cubic feet of air from this garage by the impinger method at 3.36 p. m. gave 0.16 milligram of lead, or 0.38 milligram per 10 cubic meters; from 300 cubic feet, during four peak periods, gave 0.14 milligram of lead, or 0.16 milligram per 10 cubic meters; from 420 cubic feet, 8 a. m. to 3 p. m., 0.07 milligram of lead, or 0.06 per 10 cubic meters; 240 cubic feet from the repair shop, 11 a. m. to 3 p. m., gave 0.05 milligram of lead, or 0.07 per 10 cubic meters. The Drinker precipitator tube, through which 150 liters of air at this garage had been passed, gave a total result of 0.01 milligram, or 0.7 milligram per 10 cubic meters. The same amount of air at 7.30 to 8 a. m. gave negative results. This apparatus had been previously tested in a chamber containing a suspension of lead bromide fumes from tetraethyl lead combustion and had given 60 milligrams of lead per 10 cubic meters, when the impinger, with the same air, had given 56 milligrams of lead per 10 cubic meters. Air absorbed by the charcoal method from this garage, in 900-liter amount, was negative for lead. The findings in this garage are summarized in Table 51. Controls on the methods used for lead analysis of air are given in Table 56.

The building of the public service corporation in Dayton, containing the garage in which most of the subjects of Group B were exposed, is constructed of modern brick and is four stories in height. The floors are all made of concrete. There are 14 large windows in the garage proper located on the ground floor, but these were practically never opened during the period covered by this examination. The net floor space is 11,772 square feet and the total window space 840 square feet, giving a window to floor ratio of 0.07. The natural illumination is inadequate, and the garage would be dark were it not for the good lighting system in use. The height of the ceiling is 13 feet, and the total cubic content of the garage is 153,000 cubic feet. The repair shop is located on the floor above the garage. The net floor space of this room is 4,781 square feet, with a ceiling height of 12 feet and a total volume of 57,700 cubic feet. The total window space is 480 square feet, giving a ratio of window to floor space of 0.08. Only two men are at work in this repair shop during the day, and at night this space is utilized for housing about 35 cars. The labor turnover at this plant is a little less than 10 per cent a year. As is seen in Table 4, page 43 of this report, most of the men in Group B have been exposed to ethyl gasoline exhaust gases for more than two years. However, the nature of the work of these men is such that the only time they are exposed to exhaust gases is when riding in the automobiles, taking them to and from their work, as well as the short time they must spend in the garage loading their cars with instruments and the few minutes in the evening prior to punching the time clock.

Table 45 shows the number of cars coming in and out of the building during the 24-hour period. These cars are usually taken out at about 6.30 a. m. and returned to the garage about 4.30 p. m. It is open throughout the day and night. The day shift is from 7 a. m. to 5 p. m. On this shift there are six men employed—one watchman, two repair men, one apprentice, one foreman, and one clerk. The next shift is from 4.30 p. m. to 1.30 a. m., at which time three repair men are on duty. On the last shift, from 10.30 p. m. to 7 a. m., only one car polisher and one tire-repair man are at work. The company has two 6,000-gallon storage tanks. The ordinary gasoline is treated with ethyl fluid (the commercial name of the different concentrated mixtures of lead tetraethyl with halogen compounds and kerosene, containing from 35 per cent to 60 per cent lead tetraethyl) at the railroad tracks across the street from the building by means of a measuring pump for delivering ethyl fluid. During the period of exposure to ethyl gasoline in this garage, up to the time of the investigation, there had been used here 174,032 gallons of gasoline and 598,000 cubic centimeters of the most concentrated form of ethyl fluid (55 per cent to 60 per cent of lead tetraethyl), or about 3.4 cubic centimeters per gallon. This corresponds to a $Pb(C_2H_5)_4$ content of 1:1,870 by volume. Table 57 gives the results of analyses of various samples of gasoline obtained during this investigation in Dayton and Cincinnati. It is evident that there is a great variation in the amount of lead in commercial ethyl gasoline and that the present tendency is for the gasoline to contain amounts considerably below the maximum, though in one instance, in Dayton, the amount of lead was in excess of that stated to be the maximum (1 part tetraethyl lead to 1,260 parts gasoline by volume). It is understood that frequently less tetraethyl lead is added to gasoline in winter than in summer, depending on the grade of gasoline in current use, mixtures as low as 1:2,160 being scheduled.[3]

The ethyl gasoline in the Dayton test garage is pumped from a stationary pump located near the front door of the garage, to a movable filling tank of 55 gallon capacity. This movable tank is wheeled around to different parts of the garage and is used for filling the cars. Practically all cars are filled during the last night shift, between 10.30 p. m. and 7 a. m. Between the hours of 7.30 a. m. and 4.30 p. m. there is very little work being done in the garage, most of the cars being in use. Between 6.30 a. m. and 7.30 a. m. cars are being brought down from overnight storage in the repair shop one by one by means of the elevator, and cars are also leaving the building from the garage through the only means of exit commonly used—the

[3] This seasonal change to the lower concentration of lead tetraethyl in the Dayton and Cincinnati territory was made in 1925 on Nov. 1, since which time the ethyl fluid has been mixed with a high-test gasoline in this territory

front door. It is at this period that the exhaust gases reach a high concentration. Between the hours of 4.30 p. m. and 5 p. m. all the cars are returned to the building, producing another period when the exhaust gases are at their highest. During this evening period the car users are exposed for a half hour or more to the polluted air of the garage, due to the fact that they are all gathered into the rear end of the building waiting for the hour to check out. It was observed that the rear door of the garage and all the windows were closed when the cars were entering and leaving the building. During the six-day observation period the rear door was open for a total of only about one hour. This lack of ventilation is favorable for the accumulation of exhaust gases. These gases were at times concentrated enough to give the observer a headache and to cause lachrymation. The garage floor is swept every morning after most of the cars have been removed. It was noted that considerable gasoline evaporated during the day. Table 46 gives the carbon monoxide determinations made at this garage. It is to be noted that the only time this gas is present to any appreciable extent is during a peak period when many cars are entering or leaving the building. On only one occasion did the carbon monoxide content in the room rise above 0.04 per cent. On this occasion two observations showed an average carbon monoxide content of 0.06 per cent. This amount of carbon monoxide was due to a congestion in the garage of about five minutes' duration caused by one of the cars becoming stalled. Sweepings from this garage were analyzed on several different occasions. The first sample from the floors, tables, and tops of radiators of garage and repair shop yielded 3.41 milligrams of lead per gram of sample. Another sample from parts of the benches of the repair shop where the dust had been undisturbed for a year yielded 5.82 milligrams of lead per gram of sample. Another sample of dust from the radiators and benches gave 22.3 milligrams of lead per gram of sample. A fourth sample of dust from the garage floor yielded 4.54 milligrams of lead per gram of sample. Three hundred cubic feet of air in the repair shop, 9 a. m. to 2 p. m., gave 0.12 milligram of lead, or 0.14 milligram per 10 cubic meters; 60 cubic feet, 4.20 to 5.20 p. m., a peak period for exhaust gases, gave 0.11 milligram of lead, or 0.65 milligram per 10 cubic meters; 900 cubic feet during two night periods, 7.30 p. m. to 2 a. m. and 5 p. m. to 1.35 a. m., gave 0.47 milligram of lead, or 0.18 milligram per 10 cubic meters. Five hundred cubic feet, from 7.35 a. m. to 3.55 a. m., gave 0.26 milligram of lead, or 0.18 milligram per 10 cubic meters; 210 cubic feet taken during four peak periods gave 0.19 milligram of lead, or 0.32 milligram per 10 cubic meters. Three Drinker precipitator air samples of 125, 150, and 150 liters each were negative for lead. Also three charcoal air samples of 1,800, 1,800, and 675 liters were negative. (See Table 52.)

The Cincinnati control garage, where no ethyl gasoline is used, is housed in a one-story building of the old-fashioned brick type. It has 5,000 square feet floor area and a ceiling height of 15 feet, with 75,000 cubic feet of air space. It is thus somewhat spacious for a repair garage but poorly illuminated and ventilated, having only eight windows on one side of the room and a single door. It is said, however, that cars are never tested in this garage, this work being done in the wide driveway in front of the building. In this driveway there are two pumps, handling ordinary gasoline and benzol gasoline, the latter being a mixture of 40 per cent benzol and 60 per cent gasoline. Four carbon monoxide determinations in this garage gave entirely negative results, confirming the impression that air conditions were good. However, the sample of dust sweepings from the benches and fixed tools in the garage yielded 2.4 milligrams of lead per gram, and sweepings from the floor proper where the cars were repaired, gave 6.19 milligrams of lead per gram. Samples of the two kinds of gasoline sold here (none of the employees examined had seen ethyl gasoline in any of the cars repaired in this garage) were negative for lead. A 20 cubic foot sample of air, 2.30 to 3.50 p. m., tested by the impinger method, gave 0.09 milligram of lead, or 1.6 milligrams per 10 cubic meters. One hundred and fifty liters by electrical precipitation were negative for lead on quantitative test. Nine hundred liters tested by the charcoal method gave 1.93 milligrams of lead, or 21.4 milligrams per 10 cubic meters. The digestion of the charcoal in the estimation of lead content involved considerable technical difficulty, so that the mean error with this method is probably larger than in other lead estimations. The amount of lead found in the nitric acid extract was proportionate, however, to the amount remaining in the moist charcoal, and the result indicates a high lead content in the air around the charcoal apparatus while this sample was being taken. The findings in this garage are summarized in Table 53.

At the Cincinnati test garage at least 80 per cent of the automobiles which were repaired used ethyl gasoline. This repair shop is a very poorly ventilated and lighted room; the only sources of ventilation are the four windows at one side of the room and a door at the end of an incline at the extreme end of the building. This door is at least 8 feet below the level of the garage. During the time when these observations were made the windows were closed and the door opened only when a car was brought in or taken out of the room. When eight or nine cars are undergoing repairs the room is quite crowded, and whenever a carburetor is being adjusted the room is quickly filled with exhaust gas and smoke, causing at times severe headaches. Table 47 shows the results of the determinations made at this place for carbon monoxide content. One sample reached a

concentration of 0.09 per cent, this high amount being caused by testing a recently overhauled car. At the time this determination was made the car was using ethyl gasoline. It would seem that with the poor ventilation provided in this repair shop, cars should not be tested at any time. Carburetors in the Cincinnati test garage are cleaned by a kerosene spray, the drippings being allowed to run into a shallow pan. The operator handles the carburetor with his bare hands, so that much of the washed-off dirt and kerosene comes directly into contact with his skin. A sample of kerosene and dirt was taken from the collecting pan just after a carburetor, from a car using ethyl gasoline, had been cleaned. This sample of kerosene gave 0.14 milligram of lead per cubic centimeter. Two samples of sweepings, from the work benches and from the floor, yielded, respectively, 17.54 and 5.18 milligrams of lead per gram of sample. Two hundred and forty cubic feet of air tested by the impinger method gave 0.18 milligram of lead, or 0.26 milligram per 10 cubic meters. Two tests by the Drinker precipitator and one by the charcoal apparatus were negative for lead. These results are summarized in Table 54. This repair shop had 2,405 square feet of floor space, 13 feet ceiling height, and 31,265 cubic feet of air space.

A few samples of dust, both atmospheric and from the floor, were taken from one of the plants where there was known heavy exposure to lead, comprising the hazard for a portion of Group E. The sweepings from one room, the workers in which were listed as having moderate exposure, gave over 200 milligrams of lead per gram of dust. It is probable that almost all of this was metallic lead. From another room where some of the heaviest exposure took place the sweepings contained much over 300 milligrams per gram of dust, too heavy a lead content to analyze by the method used. The impinger air samples in these two rooms gave 0.43 milligram of lead in 60 cubic feet and 17.95 milligrams in 125 cubic feet, respectively, or 2.5 and 51 milligrams per 10 cubic meters. A sample from what was probably the most dangerous room gave 26.23 milligrams of lead in 60 cubic feet, or 155 milligrams per 10 cubic meters, all lead oxides. Another room, also dangerous, in a 60 cubic foot sample showed 2.37 milligrams of lead, or 14 milligrams per 10 cubic meters. One poorly ventilated room where lead is melted showed 4.85 milligrams in 70 cubic feet, or 24.4 milligrams per 10 cubic meters. Out of 14 carbon monoxide determinations in various parts of the plant, only 3—and these were 3 out of the 4 made in this last room—gave positive results. These three all showed 2 parts per 10,000. One other room where lead was melted yielded 1.19 milligrams of lead by the impinger method in 60 cubic feet, or 7 milligrams per 10 cubic meters. A room which was thought to be removed from contact with lead

gave 0.45 milligram in 60 cubic feet, or 2.6 milligrams in 10 cubic meters. Table 55 summarizes the findings.

The lead content of the feces of apparently normal persons, which is shown to be rather uniformly present in Section IV of this report, may in part be explained by lead in the air as in the Cincinnati control garage. Lead in drinking water is also a possible source, and samples were analyzed from Dayton, from Cincinnati, and from one of the plants furnishing subjects of Group E. Table 48 shows the results of these analyses.

It was thought that differences in plumbing practice as regards the use of lead pipes in different sections of the country might have some influence on the question. Telegrams directed to various health authorities brought the following responses:

From Dayton, Ohio: "All water service pipes up to and including 1½-inch are lead from the main to the curb. In very few residences lead pipes are used within buildings."

From Cincinnati: "Lead lines have nearly disappeared inside of houses, not over 10 per cent remaining. Water service from main in street to meter is lead in 95 per cent of cases. Chief Plumbing Inspector Dowd says less lead in use in Cincinnati than most cities."

From Cleveland: "1909 water regulations require service pipes between stopcock at main and stopcock at curb to be lead in pipes having 1-inch waterway or less. If pipe is over 1 inch and not exceeding 2½ inches waterway it shall be of lead or lead lined. Further, all pipes between stopcock at curb and buildings shall be of lead or lead lined up to and including 2½ inches waterway. Probably 75 per cent of domestic consumers receive their water supply through lead pipe, accordingly. Tests made in our laboratory fail to show solubility of lead with city water in its present degree of hardness and hydrogen content."

From Chicago: "Service pipes from street main to property line 1 inch to 2 inches are lead. No lead used inside of property line for 20 years. Sizes exceeding 2 inches, cast iron."

From Baltimore: "No lead pipe now used. Have written detailed statement." Later advices show the use of lead-lined pipe.

From Philadelphia: "Regarding lead pipe, bureau of water states all water service up to 1½ inches are of this material."

From Boston: "Boston possibly has about 60 miles of lead pipe, all less than 2 inches in diameter."

From Brookline, Mass.: "Brookline uses 1 foot of lead pipe to connect with private supply pipes. Lead pipes used extensively in older houses."

Two years' consecutive mineral analyses of tap water by city laboratories in Dayton and Cincinnati are shown in Tables 49 and 50.

SECTION VI

REPORTED INJURIES FROM ETHYL GASOLINE

Perhaps the most important evidence as regards the possible harmful effects of ethyl gasoline was obtained by inquiry in the regions where it had been longest used. This, however, is largely subjective, and therefore difficult or impossible to evaluate. City and State health authorities and labor leaders, who are in a position to know if the use of tetraethyl lead, which is now universally appreciated to be very dangerous in its undiluted form, had caused any known serious results when diluted in gasoline in their respective jurisdictions, gave absolutely negative evidence as to any such harmfulness.

It might easily happen that on account of labor turnover and the disinclination of susceptible persons to remain at work where they were subject to a possible hazard of this sort, those who had been injured would not be found by an examination such as that detailed in the preceding sections of this report. Each employee examined was therefore questioned confidentially as to any rumors which he may have heard, or any knowledge or suspicion which he might have, regarding injuries or accidents from the use of ethyl gasoline. It was fortunate that the workers examined appreciated the impartial nature of this inquiry and the confidential terms of the examination. Many stories were elicited of the very serious poisonings which occurred at the blending plant where lead tetraethyl was mixed with halogens to form concentrated ethyl fluid. This plant was located near Dayton, Ohio. This, of course, was not the information being sought, and the subject's attention was directed to the use of ethyl gasoline itself. From the persons examined or in some other way occasionally a story was brought out in which some one was said to have thought it possible that ethyl gasoline was the cause of an injury. These stories, when obtained at the time of examination, were put down on separate slips of paper and not in connection with the subject's name or identification in any way. It was made clear to the subject that he could not be brought into any connection with the information given.

As a control over this method of eliciting information, similar questions were asked of the subjects in Group E, those exposed to a definite lead hazard. The response in this case was overwhelming. All who had been in the plants any length of time knew of repeated cases of lead poisoning which had occurred, and in some departments these were said to be very frequent—several in a week or in a single day.

The information obtained as a result of inquiries in the other groups was as follows:

One filling station attendant in another city was said to have died, and his death was connected by some people with the use of ethyl gasoline. This city was visited. A physician present at the operation stated that the death was clearly from purulent appendicitis.

One woman was supposed to have been made sick by the use of ethyl gasoline in the golf-stick factory where she worked. She was seen, and it was found that no ethyl gasoline was used in this factory and that her illness, from which she had recovered, was duodenitis with jaundice.

One filling station attendant was said to have suffered from the handling of ethyl gasoline. He was visited, and said that he had had a badly enlarged heart for many years and that he had stopped work because he became short of breath. The sleeplessness from which he suffered from time to time was caused by this shortness of breath. He had to remain upright to breathe with any comfort.

One man was said to have had a nervous breakdown from the use of ethyl gasoline in an aviation field. He was visited, his own physician interviewed, and a detailed history of the case was taken. The correct diagnosis appeared very clearly to be epidemic encephalitis, as was agreed without question by all the physicians and consulting neurologists who had to do with his case. No ethyl gasoline was used at that aviation field.

A newspaper account of a fatality from inhaling fumes from the tank of an automobile in a city near Dayton was investigated. The best information obtainable was that no ethyl gasoline was sold in this city. A visit to the father of the boy who died revealed, however, that the father had used ethyl gasoline in his own car, but it was found that the gasoline with which the boy was cleaning his brother's car when he died was not ethyl gasoline at all but gasoline containing another added product. This product was present in such a small quantity that it would seem likely that the boy's death was due not to that product but to the fumes of gasoline itself.

In no case was any evidence obtained as to harmful effects from ethyl gasoline.

TABLE 1.—*Industrial exposure to lead other than to ethyl gasoline*

PERCENTAGE

Groups	None	Very slight, present and past	Slight, past	Moderate, past	Slight, present	Moderate, present	Severe, present, 1 month or less	Severe, present, more than 1 month	Total
Car users:									
No ethyl gasoline (A)	58	6	33	3	0	0	0	0	100
Ethyl gasoline (B)	42	29	26	4	0	0	0	0	100
Garage and gasoline workers:									
No ethyl gasoline (C)	71	19	5	5	0	0	0	0	100
Ethyl gasoline (D)	67	11	21	2	0	0	0	0	100
Exposed to lead dusts (E)	0	0	0	0	7	41	15	38	100

NUMBER OF PERSONS

A	21	2	12	1	0	0	0	0	36
B	32	22	20	3	0	0	0	0	77
C	15	4	1	1	0	0	0	0	21
D	38	6	12	1	0	0	0	0	57
E	0	0	0	0	4	25	9	23	61
Total	106	34	45	6	4	25	9	23	252

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TABLE 2.—*Length of exposure to any gasoline*

PERCENTAGE

Exposure to any gasoline	Users of automobiles		Garage workers and gasoline handlers		Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	
Less than 6 months	14	16	19	4	12
1 year	14	12	14	18	14
2 years	6	21	5	14	14
3 years	17	12	5	23	15
4 years		3	24	9	6
5 years	19	10		7	10
6 years	6	6	5	11	7
7 years	6	3	10	2	4
8 years	8	8	5	2	6
9 years	3	3		2	2
10 years		3	10	5	4
11 years		1		2	1
12 years	3	1		2	2
13 years		1			1
14 years					
15 years and over	6	1	5	2	3
Total	100	100	100	100	100

NUMBER OF PERSONS

Less than 6 months	5	12	4	2	23
1 year	5	9	3	10	27
2 years	2	16	1	8	27
3 years	6	9	1	13	29
4 years		2	5	5	12
5 years	7	8		4	19
6 years	2	5	1	6	14
7 years	2	2	2	1	7
8 years	3	6	1	1	11
9 years	1	2		1	4
10 years		2	2	3	7
11 years		1		1	2
12 years	1	1		1	3
13 years		1			1
14 years					
15 years and over	2	1	1	1	5
Total	36	77	21	57	191

TABLE 3.—*Hours per day for which automobiles were used*

Hours	Percentage		Number of persons	
	Persons using gasoline free from lead (Group A)	Persons using ethyl gasoline (Group B)	Persons using gasoline free from lead (Group A)	Persons using ethyl gasoline (Group B)
Less than 1	----	1	----	1
1	14	12	5	9
2	22	14	8	11
3	11	8	4	6
4	22	25	8	19
5	8	10	3	8
6	14	17	5	13
7	3	4	1	3
8	6	4	2	3
9	----	4	----	3
10	----	1	----	1
Total	100	100	36	77

TABLE 4.—*Length of exposure to ethyl gasoline*

PERCENTAGE

Months	Users of automobiles with ethyl gasoline (Group B)	Garage workers and gasoline handlers exposed to ethyl gasoline (Group D)	Total
0-2	21	5	14
3-5	8	5	7
6-8	5	11	7
9-11	----	14	6
12-14	5	5	5
15-17	1	2	1
18-20	4	4	4
21-23	1	2	1
24-26	18	9	14
27 and over	36	44	40
Total	100	100	100

NUMBER OF PERSONS

0-2	16	3	19
3-5	6	3	9
6-8	4	6	10
9-11	----	8	8
12-14	4	3	7
15-17	1	1	2
18-20	3	2	5
21-23	1	1	2
24-26	14	5	19
27 and over	28	25	53
Total	77	57	134

TABLE 5.—*Length of exposure in group exposed to lead dusts (Group E)*

Months	Percentage	Number of persons	Months	Percentage	Number of persons
0–5	38	23	48–53	5	3
6–11	11	7	54–59	2	1
12–17	5	3	60–65		
18–23	7	4	66–71		
24–29	7	4	72–77	2	1
30–35	5	3	78 and over	7	4
36–41	13	8			
42–47			Total	100	61

TABLE 6.—*Distribution of persons according to age*

PERCENTAGE

Age in years	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
15–19		12	5	2	15	8
20–24	3	17	9	18	28	17
25–29	11	19	48	11	16	18
30–34	23	17	24	16	11	17
35–39	23	15	5	5	8	12
40–44	8	13	5	9	10	10
45–49	6	6		9	7	6
50–54	8	1	5	12	5	6
55–59	6			7		2
60–64	6			5		2
65–69	3			5		2
70–74	3			2		1
All ages	100	100	100	100	100	100
Median age	37	31	26	39	26	32

NUMBER OF PERSONS

15–19		9	1	1	9	20
20–24	1	13	2	10	17	43
25–29	4	15	10	6	10	45
30–34	8	13	5	9	7	42
35–39	8	12	1	3	5	29
40–44	3	10	1	5	6	25
45–49	2	5		5	4	16
50–54	3	1	1	7	3	15
55–59	2			4		6
60–64	2			3		5
65–69	1			3		4
70–74	1			1		2
All ages	35	78	21	57	61	252

Individual Findings

(Large Tables Nos. 7, 8, 9, 10, 11)

NOTES

[1] *Other lead.*—In the case of Groups A, B, C, and D, the numbers 0–3 indicate the relative exposure to lead other than tetraethyl, 0 meaning none; 1, very slight, present or past; 2, slight, past; 3, moderate, past.

In the case of Group E the symbols M, Sl, S, and SS are used, M indicating slight, present; Sl, moderate, present; S, severe, present, one month or less duration; SS, severe, present, more than one month. See explanation in Section II of this report (pp. 12–13).

[2] *Ethyl lead.*—Nos. 1–4 indicate the subgroups into which persons of the test groups (B and D) were classified as to exposure to ethyl gasoline, 4 being the most exposed subgroup. The classification was made separately for Groups B and D, the workers in each group being divided into four approximately equal classes. Therefore, the exposure occurring in any subgroup in the B group does not correspond exactly to the exposure in the subgroup of the same number in the D group. (See pp. 13–14.)

[3] *Lines 7–14. Measurements of strength in muscles of forearm.*—The values given are the medians, in pounds, of the six different measurements taken, in lines 7–10, and of the three different measurements taken for each item, in lines 11–14. Unk. means unknown, test not performed.

[4] *Vision.*—Acuity is tabulated for the better eye only; if glasses were worn, corrected vision was used. The readings were made at 15 feet. Only the denominator of the fraction is used in the table, the numerator always being 15.

[5] *Lines 19–39.*—Deviations from normal similar to those found in some cases of lead poisoning are indicated by a plus sign, absence of such deviation by 0. In the case of color, P means pale, Y yellowish, Py pale and yellowish, and C colored (natural dark skin).

[6] *Nutrition.*—G means good, F fair, and P poor.

[7] *Red cells* are given in millions per cubic millimeter.

[8] *Stippling.*—Numbers 2–9 indicate grouping based on stippled cells per 100,000 red cells; 2 means no stippling; 3 and 4, questionable, 3 meaning 1–3 very finely stippled cells and 4 meaning over 3 very finely stippled cells; 5–9, definite, 5 meaning 1–2 definitely stippled cells; 6, 3–6 cells; 7, 7–20 cells; 8, 21–100 cells; and 9, over 100 cells, per 100,000 red cells.

TABLE 7.—*Individual findings in Group A: Users of automobiles with no ethyl gasoline*

1. Case number	4	37	43	131	142	166	229	237	257
2. Other lead [1]	0	0	0	0	0	0	0	0	0
3. Ethyl lead [2]	0	0	0	0	0	0	0	0	0
4. Age	41	30	35	30	38	60	66	33	31
5. Height, in inches	66	73	70¼	64	69	66	71	66¼	69½
6. Weight, in pounds	143	199	191	117	147	124	174	136	181
7. Wrist extensors [3]	15½	20	21	15	19½	19	16	23½	27½
8. Finger extensors [3]	9½	15½	13	8	18	13	9½	15	13¼
9. Wrist flexors [3]	32	40½	34	20½	39	38	35	39	39½
10. Finger flexors [3]	23½	31	26½	17½	30	29	23	29½	24
11. Right-wrist extensors [3]	17	20	22	17	24	22	20	25	29
12. Left-wrist extensors [3]	15	20	20	12½	17	14	10	22	25
13. Right-finger extensors [3]	9	17	10	8¼	19	15	9	14	14
14. Left-finger extensors [3]	9¾	15	16	7½	15	12	10½	16	12
15. Systolic pressure (sitting)	140	136	142	124	144	150	166	136	162
16. Pulse pressure (sitting)	86	42	42	36	58	50	66	54	74
17. Pulse pressure (recumbent)	76	48	48	56	64	68	92	56	78
18. Vision [4]	15	20	20	15	15	15	40	15	15
29. General health [5]	0	0	0	0	0	0	0	0	0
20. Color [5]	0	0	0	0	0	0	0	0	0
21. Rate of tiring [5]	0	0	0	0	0	0	0	0	0
22. Muscle strength [5]	0	0	0	0	0	0	0	0	0
23. Pain in joints [5]	0	0	0	+	+	0	0	0	0
24. Constipation [5]	0	0	0	0	+	0	+	0	+
25. Appetite [5]	0	0	0	0	0	0	0	0	0
26. Nausea [5]	0	0	0	0	0	0	0	0	+
27. Abdominal pains [5]	0	0	+	0	0	0	0	0	0
28. Taste [5]	+	0	0	0	0	0	0	0	0
29. Tongue coated [5]	0	0	0	+	0	+	0	0	+
30. Pyorrhea [5]	0	0	0	0	0	0	0	+	0
31. Lead line [5]	0	0	0	0	0	0	0	0	0
32. Headache [5]	0	0	0	+	+	0	0	0	0
33. Numbness [5]	0	0	0	0	0	0	0	0	0
34. Other paræsthesias [5]	0	0	0	0	0	0	0	0	0
35. Twitchings [5]	0	0	0	0	0	0	0	0	0
36. Impaired sensation [5]	0	0	0	0	0	0	0	0	0
37. Tremors [5]	0	0	0	0	+	0	0	0	0
38. Patellar reflex [5]	0	0	0	0	0	0	+	0	0
39. Achilles reflex [5]	0	0	0	0	0	0	+	0	0
40. Nutrition [6]	G	G	G	F	F	F	G	G	G
41. Hemoglobin percentage	96	93	95	85	Unk.	100	90	100	90
42. Red cells [7]	4.69	4.59	5.17	4.75	4.83	5.06	4.59	5.07	4.90
43. Stippling [5]	2	2	2	2	2	3	2	2	2
44. Milligram lead in feces	0.39	-------	0.11	0.00	0.02	0.35	0.29	0.50	0.01
45. Milligram lead per gram feces	0.0057	-------	0.0042	0.0000	-------	-------	0.0031	-------	0.0037
46. Milligram lead per gram ash	0.220	-------	0.275	0.000	0.010	0.121	0.060	0.150	0.020

See notes on p. 45.

TABLE 7.—*Individual findings in Group A: Users of automobiles with no ethyl gasoline*—Continued

	280	302	312	322	335	342	354	452	540	568	621	622	638
2	2	0	2	0	0	1	2	2	2	2	2	0	3
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	28	29	49	46	40	31	35	55	25	58	52	51	33
5	68¾	73	70¾	69	68	64½	65	65¼	71	69½	65	71	67
6	160	135	150	201	174	136	123	176	164½	163	139	157	143
7	19½	14	21	20	17	9	19¼	14½	16	16½	21½	15	18½
8	10	5½	15¼	13	9½	5	9½	10	6¼	13½	10	10	11½
9	38	25½	36½	50	37½	14½	30½	29	33	32	38½	38	36
10	25½	17	27½	38	31½	8½	26	19¾	18	27½	25	27	29
11	21	19	22	20	15	10	22	17	18	19	20	18	20
12	18	10½	20	20	19	9	16½	14	16	16	22	13	18
13	9	4¾	16	13	9¼	6	7¼	10	6	14	7¼	10	12
14	13	7	15	13	13	4½	11	10	6½	13	14½	8	11¾
15	152	110	126	144	140	116	130	170	136	150	116	144	120
16	74	36	40	54	40	40	50	64	48	70	42	54	46
17	104	60	52	42	38	36	42	80	48	78	52	40	64
18	15	15	15	15	15	15	12	15	15	15	40	25	15
19	0	0	0	0	0	0	0	0	0	0	0	0	0
20	C	0	0	0	0	0	P	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	+	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0
23	+	0	0	0	0	0	0	0	0	0	+	0	0
24	0	0	0	0	0	+	+	0	0	0	0	0	0
25	0	0	0	0	0	0	0	+	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	+	0	0	0	+	+	0	0	0	0	0	0
29	+	+	0	+	0	+	0	+	+	+	+	+	0
30	0	0	+	0	+	0	+	+	0	+	+	0	+
31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	+	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	+	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	+	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
40	G	P	F	G	G	G	F	G	F	G	F	G	G
41	92	88	85	93	95	90	92	94	94	100	80	100	93
42	4.77	5.59	4.73	4.98	5.16	5.54	5.09	4.88	4.61	5.05	4.84	5.06	4.90
43	4	3	2	2	2	2	2	2	2	8	2	2	2
44	0.13	0.07	1.05	0.22	0.33	0.24	0.02	0.43	------	0.31	0.29	0.27	------
45	0.0033	0.0023	0.0057	0.0018	0.0021	0.0027	0.0003	0.0112	------	0.0013	0.0024	0.0011	------
46	0.100	0.070	0.101	0.100	0.061	0.104	0.033	0.518	------	0.086	0.046	0.090	------

Items numbered as on p. 46.

TABLE 7.—*Individual findings in Group A: Users of automobiles with no ethyl gasoline*—Continued

1	660	695	721	722	747	765	784	823	841	919	923	954	961	1,000
2	0	0	1	0	0	0	2	2	0	0	2	2	2	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	22	28	32	39	35	35	44	70	30	39	37	33	60	50
5	65	64	67	69	68½	68½	68	64½	67½	66	69	69	71	71
6	141	120	141	234	134	189	155	121½	126	146	124	141	205	173
7	17½	14	21	16½	17½	11	21	17	13	16½	17	18½	19	23
8	7	7½	17	11	15½	6½	15½	13	7½	14¾	11	10½	17½	14
9	36½	21	37½	40	37	27½	34	29½	24½	35	26½	32	30½	38½
10	18	15½	27	26½	30½	19	25½	21	18½	27	21½	26½	28	29½
11	19	12	26	16	20	11	23	17	13	18	17	18	17½	23
12	16	16	19	17	15	11	21	17	12	13½	17	20	22	24
13	5¼	5	18	13	17	5	17	13	8	14½	11	8¼	6¼	13
14	8¾	8¾	17	11	14	8	15	13	7	15	11	12	8¼	16
15	126	136	142	118	140	114	142	120	146	116	150	122	164	118
16	45	58	44	36	56	30	62	46	60	38	74	44	62	40
17	68	66	56	50	64	34	60	70	60	48	100	48	58	64
18	15	15	15	15	15	15	15	20	15	15	15	15	20	15
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	Y	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	+	0	0	0	0	0	+	+	0
24	0	0	0	0	0	+	0	0	0	0	+	0	+	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	+	0	0	0	0	0	0	0
28	0	0	0	0	+	0	0	0	0	0	0	0	+	0
29	0	0	+	+	+	0	0	+	0	0	0	0	+	+
30	0	0	0	0	0	+	+	+	0	0	0	+	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	+	0	0	0	+	0	0	0	+	0
33	0	0	0	0	0	0	0	0	0	0	0	0	+	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	+	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	+	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	G	F	G	G	F	G	G	F	F	G	F	F	G	G
41	90	92	90	90	100	90	90	85	90	95	85	95	85	92
42	4.63	4.71	5.04	5.01	4.77	5.36	5.06	4.67	4.77	5.26	4.13	5.02	5.04	5.05
43	2	2	5	2	2	2	5	3	2	2	2	3	2	7
44	------	0.55	------	0.10	0.37	0.14	0.43	0.31	0.19	0.92	0.41	0.25	0.26	0.04
45	------	0.0043	------	0.0018	0.0020	------	0.0025	0.0048	0.0013	0.0063	0.0033	0.0015	0.0027	------
46	------	0.138	------	0.083	0.032	0.032	0.054	0.109	0.040	0.400	0.064	0.096	0.104	0.022

Items numbered as on p. 46.

TABLE 8.—*Individual findings in Group B: Users of automobiles with ethyl gasoline*

1. Case number	14	24	48	58	60	73	88	99	100
2. Other lead [1]	0	1	1	1	2	0	2	0	1
3. Ethyl lead [2]	1	4	3	2	2	3	2	4	4
4. Age	29	23	38	21	24	19	18	31	39
5. Height, in inches	70	63	66½	69¾	66	70	69	70	63¼
6. Weight, in pounds	104	143	156	142	140	130	146	165	139
7. Wrist extensors [3]	12½	20½	20	21½	17	14½	18	18½	15½
8. Finger extensors [3]	10½	8¾	8	12	8½	6½	13½	12	10
9. Wrist flexors [3]	26½	37	46	38	30	24	35	38	34
10. Finger flexors [3]	18½	19	47	24½	21½	17	22½	31½	30½
11. Right-wrist extensors [3]	14½	23¼	21	25	20	13	21	19	14
12. Left-wrist extensors [3]	12	18	19	19	17	15	18	18	17¾
13. Right-finger extensors [3]	11¾	8¼	7½	13	7	7¼	19	9	8
14. Left-finger extensors [3]	9¼	9¼	9	10	11	6¼	11	16	12
15. Systolic pressure (sitting)	108	136	126	108	116	104	130	138	134
16. Pulse pressure (sitting)	38	46	42	34	30	34	30	60	54
17. Pulse pressure (recumbent)	56	52	68	46	58	52	38	76	70
18. Vision [4]	15	15	15	15	15	15	15	15	15
19. General health [5]	0	0	0	0	0	0	0	0	0
20. Color [5]	0	0	Py	0	0	0	0	0	0
21. Rate of tiring [5]	0	0	0	0	0	0	0	0	0
22. Muscle strength [5]	0	0	0	0	0	0	0	0	0
23. Pains in joints [5]	0	+	0	0	0	0	0	0	0
24. Constipation [5]	0	0	+	0	+	+	+	0	0
25. Appetite [5]	0	0	0	0	0	0	0	0	0
26. Nausea [5]	0	+	0	0	0	0	0	+	0
27. Abdominal pains [5]	0	+	0	0	0	0	0	+	0
28. Taste [5]	0	0	+	0	+	0	0	0	0
29. Tongue coated [5]	+	+	+	0	+	0	0	+	0
30. Pyorrhea [5]	0	0	0	0	0	0	0	0	0
31. Lead line [5]	0	0	0	0	0	0	0	0	0
32. Headache [5]	0	0	0	0	0	+	0	0	0
33. Numbness [5]	0	0	0	0	0	0	0	0	0
34. Other paræsthesias [5]	0	0	0	0	+	0	0	0	0
35. Twitchings [5]	0	0	0	0	0	0	+	0	0
36. Impaired sensation [5]	0	0	0	0	0	0	0	0	0
37. Tremors [5]	0	0	0	0	0	0	0	0	0
38. Patellar reflex [5]	0	0	0	0	0	0	0	0	0
39. Achilles reflex [5]	0	0	0	0	0	0	0	0	0
40. Nutrition [6]	P	G	G	G	F	F	G	G	G
41. Hemoglobin percentage	84	92	90	90	85	85	100	98	95
42. Red cells [7]	4.98	4.86	5.09	5.04	5.13	5.07	5.14	5.06	4.82
43. Stippling [8]	2	5	2	2	2	3	2	5	2
44. Milligram lead in feces	0.08	0.10	0.47	------	0.26	0.36	0.41	0.38	------
45. Milligram lead per gram feces	0.0018	0.0011	0.0044	------	0.0018	0.0027	0.0036	0.0020	------
46. Milligram lead per gram ash	0.071	0.053	0.188	------	0.063	0.116	0.137	0.076	------

See notes on p. 45.

TABLE 8.—*Individual findings in group B: Users of automobiles with ethyl gasoline*—Continued

1	110	122	143	160	170	179	207	210	222	223	246	270	284	299
2	2	2	0	0	1	2	1	0	0	1	2	0	0	1
3	2	2	3	2	3	4	4	2	4	4	2	1	1	3
4	37	20	33	27	41	38	30	19	29	29	27	24	33	36
5	63	70½	70	71	67	69½	67½	67	62¼	69¼	65	76	65	70
6	108	152	182	136	130	181	130	128	128	151	154	161	144	131
7	15¾	18½	14¼	20	15½	23½	16	19	17	19	22	21½	15	20½
8	7¾	7½	9½	7¾	7¾	9½	9¼	10	7¼	7½	16	7	7	6½
9	28	29	32½	36½	21	44½	28	29	24	43	36½	25	29	33
10	23	21	20	28	16	24	21½	20½	18	30	26½	15½	15¼	16½
11	17	21	12	23	17	24	18	20	16	20	25	23	16	19
12	14	18	17	16	13	22	13	16	19	18	20	20	15	21
13	7	7½	9½	7½	7½	9	11	8½	6	7¼	20	6¾	8	6¼
14	9	7¾	10	7¾	9¾	12	8½	11	8½	7½	16	7¾	6	7
15	110	122	144	126	120	126	126	130	122	148	120	130	130	104
16	32	34	44	50	40	52	46	46	42	76	48	48	48	32
17	32	68	58	68	48	60	40	64	56	76	40	60	50	56
18	15	15	15	15	15	15	15	15	15	15	30	20	30	20
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	+	0	0	0	0
24	0	0	0	+	0	0	+	0	0	0	0	+	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	+	0	0	0
27	0	0	0	0	0	0	+	0	0	0	0	0	0	0
28	0	+	0	0	+	0	+	0	0	0	+	0	0	0
29	0	0	0	0	0	+	+	0	0	+	+	+	0	0
30	+	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	+	0	0	+	0	0	0	0	+	0	+	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	+	0	0	0	0	0	0	+	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	+	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	F	G	G	F	F	G	F	G	F	F	G	F	G	F
41	70	95	97	92	80	95	90	80	92	Unk.	95	85	100	90
42	5.10	5.12	5.25	5.14	5.06	4.92	4.82	4.59	4.78	4.82	4.93	4.38	4.82	5.10
43	2	2	2	2	2	2	2	2	2	2	2	2	5	2
44	1.14	------	0.97	------	0.17	------	------	0.57	0.25	0.61	0.60	------	0.17	------
45	0.0114	------	0.0050	------	0.0031	------	------	0.0041	0.0012	0.0035	0.0036	------	0.0009	------
46	0.438	------	0.147	------	0.144	------	------	0.071	0.051	0.094	0.188	------	0.081	------

Items numbered as on p. 49.

TABLE 8.—*Individual findings in Group B: Users of automobiles with ethyl gasoline*—Continued

	320	329	350	352	369	374	380	391	405	414	421	430	443	467
2	2	1	0	2	d	2	.0	0	1	0	2	0	3	2
3	2	4	3	2	3	2	1	3	4	1	2	3	2	3
4	30	40	23	24	45	42	25	41	34	19	28	35	35	34
5	67	66¾	69¾	68	66	65½	65¾	66¼	69	67	67	65½	67½	66½
6	124	127	150	121	133	139	119	119	125	123	143	117	140	112
7	16½	15½	19½	14	16½	18	19	14	18	12½	Unk.	12½	18	16
8	6½	8¼	8¼	5¾	13	9¾	9½	6	12	4½	Unk.	9¾	8	5½
9	24	36	39	22½	32	34	26	21½	30½	21	Unk.	22½	35½	28
10	22	27	21½	13	26	25	24½	20	24	13½	Unk.	16	25½	19½
11	16	12	21	16½	19	20	18	14	18	14	Unk.	15	19	17
12	17	17½	19	12	13	17	19	14	17	12	Unk.	12	17	16
13	20	8	8	6	13	7½	9½	5¾	12	4¾	Unk.	9	7½	5¼
14	22	8½	8½	6¼	11¾	11¾	13	7	11½	4¾	Unk.	10½	8½	5½
15	126	114	130	116	112	122	122	134	116	120	124	110	150	102
16	44	44	62	68	40	38	50	44	58	42	48	40	56	30
17	46	42	80	80	46	38	60	52	62	44	56	54	24	44
18	15	15	15	15	30	15	30	15	15	15	15	15	15	15
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	+	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	+	0	0	0	0	0	0	0	0	0	0	0	+
24	+	0	0	0	0	0	0	0	+	0	0	+	0	0
25	+	0	0	0	0	0	0	0	0	0	0	+	0	0
26	+	0	0	0	0	+	0	0	0	0	0	0	+	+
27	+	0	0	0	0	0	+	0	0	0	0	0	0	0
28	0	0	0	0	+	0	+	0	0	0	+	+	0	0
29	0	0	0	0	0	+	0	0	+	0	0	+	0	+
30	0	0	0	0	0	0	0	0	0	0	0	0	+	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	+
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	+	0	0	0	0
38	0	0	0	0	+	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	F	F	G	F	F	F	F	F	G	G	G	F	G	F
41	80	90	94	55	95	92	92	90	88	90	85	Unk.	100	80
42	4.39	4.88	4.69	4.02	5.01	4.84	5.20	5.15	5.12	4.95	4.74	5.05	5.03	4.70
43	4	2	2	2	2	2	2	2	2	2	2	2	6	3
44	------	0.16	0.22	0.23	0.17	0.38	1.07	0.00	0.38	------	0.15	1.05	0.40	0.20
45	------	0.0023	0.0051	0.0017	0.0022	0.0040	0.0046	0.0000	0.0020	------	0.0015	0.0034	0.0031	0.0011
46	------	0.038	0.147	0.059	0.089	0.253	0.082	0.000	0.060	------	0.052	0.083	0.076	0.028

TABLE 8.—*Individual findings in Group B: Users of automobiles with ethyl gasoline*—Continued

1	476	484	491	530	558	572	584	603	610	623	629	643	654
2	0	2	3	1	1	2	1	0	1	2	2	0	0
3	1	4	1	3	3	1	3	2	4	4	3	4	2
4	18	32	19	45	35	47	35	18	43	34	33	27	26
5	65¼	66	68	68	66½	68	71½	68	67¼	65	70	67	69
6	120	146	128	154	144	166	161	141	136	118	173	123	150
7	16½	26	20	17	18	Unk.	19½	17	15	19	Unk.	15½	20½
8	12	6¼	12½	9	9½	Unk.	12¼	11¾	6½	7	Unk.	8	7¼
9	28	51	39½	36	29½	Unk.	36	31½	32	28	Unk.	25½	37½
10	19½	26	30	23¾	25	Unk.	19	25	23½	23	Unk.	20	22½
11	18	27	20	19	18	Unk.	21	17	14	18	Unk.	19	23
12	16	25	20	17	18	Unk.	18	17	15¾	20	Unk.	15	18
13	16	6½	13	8¾	10	18	12½	12	5½	6½	Unk.	7	6½
14	10	7¼	12	9¼	9	17	12	10½	7	8	Unk.	9½	9
15	106	122	138	134	118	122	128	136	134	112	144	116	116
16	28	36	64	38	44	40	42	58	46	44	66	38	38
17	38	58	72	44	54	44	56	80	62	50	50	66	56
18	15	15	15	15	15	20	15	15	15	15	15	15	15
19	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	+	0	+	+	0	0	+	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	+	0	+	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	+	0
28	0	+	0	0	0	0	0	+	0	0	0	0	0
29	0	+	+	0	+	0	+	+	+	0	+	0	0
30	0	0	0	0	0	+	0	0	0	+	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	+	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0		0	0	0	0	0	0	0	0	0	0	0
40	F	G	G	F	G	G	G	G	F	F	G	F	G
41	95	92	95	95	88	95	90	90	95	80	90	95	95
42	4.79	4.73	5.01	5.41	5.26	4.79	4.91	4.53	4.82	4.48	5.05	4.82	4.68
43	5	2	2	2	2	2	2	2	2	2	5	3	2
44	0.11	-------	0.27	0.39	0.38	0.22	0.36	0.11	0.23	-------	-------	0.14	0.09
45	0.0031	-------	0.0041	0.0032	0.0034	0.0014	0.0021	0.0018	0.0038	-------	-------	-------	0.0041
46	0.110	-------	0.122	0.081	0.093	0.076	0.067	0.092	0.077	-------	-------	0.286	0.056

TABLE 8.—*Individual findings in Group B: Users of automobiles with ethyl gasoline*—Continued

1.	668	671	681	686	708	731	752	775	792	804	817	821	822	830
2.	0	1	1	0	0	0	0	1	0	0	2	2	1	3
3.	4	3	1	1	4	1	4	2	2	3	1	4	4	1
4.	22	29	44	17	23	49	29	41	22	19	46	44	43	20
5.	67¼	66½	68½	70	70½	65	69¼	63¼	67	66¼	73	66	66½	70
6.	132	123	196	147	171	144	135	179	141	119	188	148	174	148
7.	15½	15½	25	14	22	18½	23	Unk.	17	15	15½	17	18½	22
8.	6¾	8¼	12	7	12	10	14	Unk.	12½	8	7½	5½	7½	10¾
9.	24½	28½	55	23	42	40	44	Unk.	27½	24½	37½	29	33½	40½
10.	16½	20	35	21½	28½	32	25	Unk.	21½	17¼	23½	18	24	36
11.	17	18	24	18	26	19	19	Unk.	20	17	16	18	20	23
12.	15	15	28	14	20	18	25	Unk.	16	14	15	18	16	21
13.	6	7½	12	7	12	10	16	Unk.	10	8	8½	5½	7	10
14.	7	7¾	21	6¾	12	10¼	12	Unk.	10½	8	7	5½	9½	11
15.	116	108	126	124	134	136	118	190	116	120	120	144	130	126
16.	44	30	34	46	54	62	44	60	28	38	34	68	38	42
17.	52	50	50	56	62	64	64	54	48	60	56	78	38	52
18.	15	15	15	15	15	30	15	15	15	15	15	15	15	15
19.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.	0	0	0	0	0	0	0	0	0	0	0	0	+	0
24.	0	+	0	0	0	+	0	0	0	0	+	0	0	0
25.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.	0	+	0	0	0	0	0	0	0	0	0	0	+	0
28.	+	0	0	+	0	0	0	0	0	0	+	0	0	0
29.	0	0	++	0	0	0	+	0	0	+	+	++	0	0
30.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35.	0	0	0	0	0	0	0	0	+	0	+	0	0	0
36.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40.	F	F	G	F	G	G	F	G	G	F	G	G	G	G
41.	92	90	100	95	90	95	92	92	95	80	90	80	92	92
42.	4.98	5.06	4.94	5.83	5.21	5.09	4.88	4.88	5.22	5.51	4.93	5.24	5.06	4.99
43.	3	2	2	2	6	2	2	2	2	3	2	3	2	2
44.	0.24	0.69	------	------	------	0.47	0.29	0.13	0.08	------	0.38	------	0.04	------
45.	0.0046	0.0049	------	------	------	0.0046	0.0047	0.0019	0.0009	------	0.0032	------	0.0004	------
46.	0.150	0.111	------	------	------	0.096	0.153	0.118	0.026	------	0.146	------	0.009	------

TABLE 8.—*Individual findings in Group B: Users of automobiles with ethyl gasoline*—Continued

1	851	860	870	883	899	909	922	930	938	964	976	982	990
2	0	2	0	1	0	2	2	0	0	1	0	1	1
3	4	2	1	3	1	1	4	1	1	3	3	1	2
4	37	35	53	27	37	25	32	27	29	43	21	21	33
5	71½	67½	64½	66½	68½	67¼	71½	71¾	70	66	71	64½	71
6	152	125	173	140	136	152	188	178	138	119	127	161	150
7	21	18	23	21½	14	19	21	19½	18½	14	19	21½	14
8	17	8	14½	9¼	12¾	11	8½	12½	11½	7½	13	10	6¾
9	48	35½	36	34	29	33½	40	28	36½	20½	33	38½	36
10	41½	23½	31½	21½	25	26	26	21	28½	20½	30	23	24
11	21	17	22	23	15	19	21	20	18	13	21	30	16
12	21	18	25	20	14	19½	20	18	19	15	17	16	13
13	15	7¼	15	9½	13	10	8½	13¾	12	7¼	12½	10	6
14	18	8¼	13	9	12	12¾	8½	9½	11	8	13¾	11½	7½
15	110	90	160	122	130	132	144	118	106	128	134	162	106
16	40	22	58	38	44	54	48	40	36	46	54	74	28
17	40	34	62	64	62	54	50	50	40	62	56	72	50
18	15	15	15	15	15	15	15	15	15	15	15	15	10
19	+	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	+	0	0	0	0	0	0	0	0
24	+	0	0	0	+	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0
26	+	0	0	0	+	0	+	0	0	0	0	0	0
27	+	0	0	0	+	0	+	0	0	0	0	0	0
28	+	0	0	0	+	0	+	0	0	0	0	0	0
29	0	0	+	+	+	0	+	0	+	0	0	0	+
30	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	+	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	+	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	+	0	0
39	0	+	0	0	0	0	0	0	0	0	0	0	0
40	G	F	G	G	F	G	G	G	F	F	F	G	G
41	90	80	90	75	95	98	94	90	95	92	95	90	92
42	4.96	4.16	4.94	4.93	4.82	5.04	4.86	5.04	4.90	5.15	4.84	5.25	4.98
43	2	5	2	2	2	2	2	2	5	2	2	2	2
44	0.13	0.15	0.28	0.41	0.30	0.53	------	0.02	0.17	0.17	0.58	------	0.21
45	------	0.0033	------	0.0016	0.0015	0.0037	------	0.0007	------	0.0018	------	------	0.0027
46	0.027	0.056	0.165	0.100	0.033	0.089	------	0.025	0.189	0.094	0.065	------	0.082

TABLE 9.—*Individual findings in Group C: Garage workers and gasoline handlers not exposed to ethyl gasoline*

1. Case number	20	67	129	154	201	288	377	409	418
2. Other lead [1]	0	0	3	0	0	0	0	0	0
3. Ethyl lead [2]	0	0	0	0	0	0	0	0	0
4. Age	33	30	28	40	29	29	26	26	34
5. Height, in inches	68	70½	69	67	68	68½	67¼	68¼	68
6. Weight, in pounds	135	165	149	139	134	143	192	133	138
7. Wrist extensors [3]	17	24½	19½	16	21½	19	27½	20½	21
8. Finger extensors [3]	7¼	14	19½	3¾	15½	11½	16½	10	16
9. Wrist flexors [3]	31	49	39½	28	42	41	39½	29½	39½
10. Finger flexors [3]	20	31	34	16	51	34½	30	24	29
11. Right wrist extensors [3]	18	25	22	17	24	22	28	20	23
12. Left wrist extensors [3]	16	24	17	16	22	17	27	21	21
13. Right finger extensors [3]	7¼	14	15	4	17	12	17	10	16
14. Left finger extensors [3]	8¾	14	14	3¾	15	10	16	11	16
15. Systolic pressure (sitting)	130	124	124	130	126	136	121	124	120
16. Pulse pressure (sitting)	48	38	50	42	71	70	35	43	45
17. Pulse pressure (recumbent)	48	42	63	46	70	74	42	56	52
18. Vision [4]	20	15	15	20	15	15	15	15	15
19. General health [5]	0	0	0	0	0	0	0	0	0
20. Color [4]	0	0	0	0	0	0	0	0	0
21. Rate of tiring [5]	0	0	0	0	0	+	0	0	0
22. Muscle strength [5]	0	0	0	0	0	0	0	0	0
23. Pains in joints [5]	0	0	0	0	0	0	0	0	0
24. Constipation [5]	0	0	0	0	0	0	0	0	0
25. Appetite [5]	0	0	0	0	0	0	0	0	0
26. Nausea [5]	0	0	0	0	0	0	0	0	0
27. Abdominal pains [5]	0	0	0	0	0	0	0	0	0
28. Taste [5]	0	0	0	0	0	+	0	0	0
29. Tongue coated [5]	0	+	0	+	+	0	+	0	+
30. Pyorrhea [5]	0	0	0	0	0	0	0	0	+
31. Lead line [5]	0	0	0	0	0	0	0	0	0
32. Headache [5]	0	+	0	+	0	+	0	0	+
33. Numbness [5]	0	0	0	0	0	0	0	0	0
34. Other paresthesias [5]	0	0	0	0	0	0	0	0	0
35. Twitchings [5]	0	0	0	0	0	+	0	0	0
36. Impaired sensation [5]	+	0	0	0	0	0	0	0	0
37. Tremors [5]	+	0	0	0	0	0	0	0	0
38. Patellar reflex [5]	0	0	0	0	0	0	0	0	0
39. Achilles reflex [5]	0	0	0	0	0	0	0	0	0
40. Nutrition [6]	G	G	G	G	F	G	G	G	G
41. Hemoglobin percentage	94	Unk.	96	90	88	94	Unk.	86	88
42. Red cells [7]	4.80	5.03	5.03	4.60	4.90	4.88	4.66	5.05	4.99
43. Stippling [8]	3	2	2	2	5	2	6	2	2
44. Milligram lead in feces	0.16	-------	0.16	0.26	0.24	0.16	-------	0.00	1.04
45. Milligram lead per gram feces	0.0032	-------	0.0017	0.0010	0.0065	0.0010	-------	0.0000	0.0053
46. Milligram lead per gram ash	0.058	-------	0.064	0.072	0.218	0.062	-------	0.000	0.259

See notes on p. 45.

TABLE 9.—*Individual findings in Group C: Garage workers and gasoline handlers not exposed to ethyl gasoline*—Continued

1	420	474	509	516	663	665	676	690	890	895	942	945
2	0	1	0	1	0	1	1	0	0	0	0	2
3	0	0	0	0	0	0	0	0	0	0	0	0
4	30	25	24	17	53	29	29	25	21	36	34	28
5	65	66	69	71½	68	65	64½	69	65¼	69½	64½	66
6	128	202	132	146	141	163	130	129	133	184	124	141
7	13	20½	17	17	24	16½	15	21	22	22	22	14¼
8	6¾	11	11	13	20½	14	10¼	14	15	18	17	5
9	32	40	28	36	45½	40½	35	30	33	56½	37½	17
10	21	31	28	28½	33½	29½	30½	21½	20½	41½	32½	8
11	12½	20	18	18	24	18	14	23	25	24	22	13
12	14	21	17	15	24	13	15	20	20	20	21	17
13	6¾	13	11	14	16	16	10½	14	11	20	20	5
14	7	11	10¾	13	21	11	9	12	9	16	14	4¼
15	128	132	152	128	125	142	121	136	118	130	120	120
16	40	28	62	56	57	66	45	74	56	40	55	40
17	48	44	68	66	67	78	64	93	55	42	64	32
18	15	15	15	15	15	20	15	15	15	15	15	13
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	P	0	0	0	P	0	0	0	0
21	+	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	+
24	+	0	0	0	0	0	+	0	0	0	+	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	+	0	0	0	0	+
27	+	0	0	0	0	0	0	0	0	0	0	+
28	0	0	+	0	0	0	+	0	0	0	0	+
29	0	+	0	+	+	+	0	+	+	0	+	0
30	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	+	0	0	0	0	0	0	0	0	0	0	+
33	0	0	0	0	0	0	+	0	0	0	0	0
34	0	0	0	0	0	0	+	0	0	0	0	0
35	0	0	0	0	+	0	+	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	G	G	G	F	F	G	F	F	G	G	F	G
41	92	95	90	88	90	98	95	95	92	94	88	88
42	4.93	4.98	4.16	4.94	5.11	5.37	4.71	5.05	4.97	4.54	5.21	5.60
43	2	4	2	3	2	2	5	5	2	2	5	2
44	------	0.11	------	0.18	0.34	0.28	0.21	0.40	0.23	1.14	0.54	0.18
45	------	0.0050	------	0.0062	0.0015	0.0021	0.0006	0.0033	0.0017	0.0061	0.0072	0.0018
46	------	0.220	------	0.514	0.079	0.117	0.042	0.103	0.082	0.285	0.159	0.078

Items numbered as on p. 55.

TABLE 10.—*Individual findings in Group D: Garage workers and gasoline handlers exposed to ethyl gasoline*

1. Case number	22	30	80	94	137	174	183	188	191
2. Other lead [1]	0	0	2	0	0	0	0	0	2
3. Ethyl lead [2]	2	2	2	1	1	3	2	4	4
4. Age	23	24	26	49	29	43	65	24	44
5. Height, in inches	68½	67	69	70¼	65¼	64	63	68	68
6. Weight, in pounds	150	132	139	186	147	186	133	226	155
7. Wrist extensors [3]	20	19	19	21½	18	17½	11½	25½	20
8. Finger extensors [3]	15½	14	11½	12½	14½	13	8	13	16
9. Wrist flexors [3]	30½	33	34½	50½	33	27½	20	42	40½
10. Finger flexors [3]	16	24	25	27½	25	19½	10¾	38	25
11. Right wrist extensors [3]	24	20	22	24	18	19	12	27	22
12. Left wrist extensors [3]	20	19	16	19	18	15	10	23¼	18
13. Right finger extensors [3]	16	16	13	12	15	13	8½	11¼	16
14. Left finger extensors [3]	15	12	10	12	14	13	7½	15	16
15. Systolic pressure (sitting)	121	148	116	128	150	122	118	146	125
16. Pulse pressure, (sitting)	50	84	46	50	75	38	36	58	53
17. Pulse pressure (recumbent)	66	88	60	58	94	60	48	38	52
18. Vision [4]	15	15	15	15	15	15	25	15	15
19. General health [5]	0	0	0	0	0	0	0	0	0
20. Color [4]	0	P	0	0	0	0	0	0	0
21. Rate of tiring [5]	0	0	0	0	0	0	0	0	0
22. Muscle strength [5]	0	0	0	0	0	0	0	0	0
23. Pains in joints [5]	0	0	0	0	0	0	0	0	0
24. Constipation [5]	0	0	0	0	0	0	0	0	0
25. Appetite [5]	0	0	0	0	0	0	0	0	0
26. Nausea [5]	0	0	0	0	0	0	0	0	0
27. Abdominal pains [5]	0	0	0	0	0	0	0	0	0
28. Taste [5]	0	0	0	0	0	0	0	0	0
29. Tongue coated [5]	0	0	+	0	+	+	0	0	+
30. Pyorrhea [5]	0	0	0	0	0	0	+	0	+
31. Lead line [5]	0	0	0	0	0	0	0	0	0
32. Headache [5]	0	0	0	0	0	0	0	0	0
33. Numbness [5]	0	0	0	0	0	0	0	0	0
34. Other paresthesias [5]	0	0	0	0	0	0	0	0	0
35. Twitchings [5]	0	0	0	0	0	0	0	0	0
36. Impaired sensation [5]	0	0	0	0	0	0	0	0	0
37. Tremors [5]	0	0	0	0	0	0	0	0	0
38. Patellar reflex [5]	0	0	0	0	0	0	0	0	0
39. Achilles reflex [5]	0	0	0	0	0	0	0	0	0
40. Nutrition [6]	G	F	F	G	G	G	G	G	G
41. Hemoglobin percentage	95	94	95	95	100	96	85	80	92
42. Red cells [7]	5.23	4.91	5.06	4.89	4.83	4.93	5.00	4.92	4.83
43. Stippling [8]	5	2	2	2	7	2	5	2	6
44. Milligram lead in feces	0.28	0.32	0.04	0.20	0.30	0.00	0.19	0.35	0.89
45. Milligram lead per gram feces	0.0023	0.0067	0.0024	0.0047	0.0018	0.0000	0.0019	0.0046	0.0057
46. Milligram lead per gram ash	0.080	0.119	0.667	0.182	0.057	0.000	0.048	0.135	0.324

See notes on p. 45.

TABLE 10.—*Individual findings in Group D: Garage workers and gasoline handlers exposed to ethyl gasoline*—Continued

1	241	250	264	267	274	292	309	348	364	385	398	422
2	0	0	2	0	2	1	0	2	0	0	0	2
3	1	1	3	4	2	3	2	3	2	2	4	1
4	45	60	39	56	22	24	33	41	47	52	38	50
5	64	59½	64	63½	68	66	71½	66	68	67½	68	64½
6	170	166	130	110	168	128	146	127	162	135	139	154
7	18	16	20	14	24½	16	17½	23½	21	19½	18½	20½
8	12½	8	14	10	11	11½	13½	15½	14½	13	12	13½
9	35½	23	35½	26½	41½	30	28½	42	41	32½	39	36
10	21½	17	30	16½	25½	24½	20½	32½	27	24½	29	28
11	19	16	20	15	25	16	21	24	21	20	20	20
12	16	16	20	13	21	17	14	23	21	18	17	21
13	12	8	14	10	14	9	15	17	17	13	13	14
14	13	8	14	9	11	13	13	14	14	14	10	13
15	120	175	110	135	140	126	122	126	142	128	122	116
16	35	60	65	45	65	66	42	44	66	48	62	68
17	67	82	60	65	98	74	48	38	66	54	75	80
18	30	15	15	100	15	15	15	15	15	20	15	15
19	0	0	0	Py	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	+	++	0	0	0	0	0	0	0	0	0	0
23	0	++	0	0	0	0	0	0	0	0	0	0
24	0	0	+	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	++	0	0	0	0	+	0
28	+	0	0	0	0	+	0	0	0	0	0	0
29	0	++	0	0	0	0	0	0	0	++	0	0
30	0	++	0	0	0	0	0	0	+	++	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	+	0	0	0	+	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	+	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	G	G	F	P	G	F	F	F	G	F	F	G
41	92	95	95	80	95	83	90	88	92	80	85	93
42	4.97	5.00	4.80	5.04	5.01	4.87	4.99	5.16	4.97	4.99	4.94	4.75
43	2	5	5	2	2	2	2	6	2	5	2	5
44	0.28	0.00	0.61	0.22	0.31	0.18	0.28	1.55	0.36	0.00	------	0.20
45	0.0042	0.0000	0.0051	0.0035	0.0091	0.0015	0.0026	0.0136	0.0018	0.0000	------	0.0037
46	0.156	0.000	0.179	0.550	0.207	0.042	0.070	0.500	0.058	0.000	------	0.111

Items numbered as on p. 57.

TABLE 10.—*Individual findings in Group D: Garage workers and gasoline handlers exposed to ethyl gasoline*—Continued

1	426	431	441	456	460	463	469	495	521	522	523	549
2	3	0	2	0	2	0	0	0	0	0	1	0
3	3	4	4	4	3	3	2	4	1	1	3	3
4	51	34	33	43	34	54	19	54	55	23	34	68
5	65	70	66¼	64	66	65½	70	66¼	73	66	69½	67
6	152	169	190	116	135	152	144	148	166	134	186	167
7	18½	21	17	15½	17	17½	14	19	25	20½	24½	18
8	8	16	12	9	13½	10	8	8	14½	11½	16	13
9	32	40½	40	29	30	29	27	27	38½	32	42½	31½
10	26	26	26½	20	21¼	20	19¼	25	35½	19½	29	18½
11	19	25	17	15	19	18	12½	16	25	24	28	18
12	18	20	17	16	16	17	16	22	25	18	24	18
13	7	18	13	9	12	11	8	7	15	12	18	12
14	8½	15	12	9	15	9	8½	9	13	11	16	13
15	140	144	136	110	120	110	114	138	122	115	138	165
16	60	66	51	48	38	45	44	42	42	35	86	75
17	62	60	46	57	30	48	60	54	42	45	85	80
18	20	30	15	30	25	30	15	15	25	15	15	15
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	P	0	0	C	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	+	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	+	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	+	0	0	0	0	0
26	0	0	0	0	0	0	0	0	+	+	0	0
27	+	0	0	0	0	0	0	0	0	0	0	0
28	0	+	0	0	0	0	0	0	+	0	+	0
29	+	0	+	+	0	+	0	+	+	0	+	+
30	0	0	0	0	0	+	0	+	0	0	+	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	+	0	0	0	0	+	0	+	0	0	0
33	0	0	0	0	0	0	0	0	0	+	0	0
34	0	+	0	0	0	0	0	0	0	+	0	0
35	0	+	0	0	0	0	0	+	0	0	0	0
36	0	+	0	+	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	G	G	G	F	F	G	F	G	G	G	G	G
41	92	85	90	92	88	80	95	95	92	92	100	88
42	5.06	4.99	4.67	4.43	3.64	4.17	4.62	5.25	5.18	5.03	5.03	4.77
43	2	5	5	5	2	7	2	7	3	2	2	2
44	0.39	0.55	0.10	0.45	0.37	0.17	-------	0.13	0.18	-------	0.80	0.35
45	0.0036	0.0023	0.0016	0.0061	0.0025	0.0059	-------	0.0018	0.0023	-------	0.0050	0.0030
46	0.118	0.098	0.063	0.328	0.103	0.213	-------	0.144	0.164	-------	0.182	0.109

TABLE 10.—*Individual findings in Group D: Garage workers and gasoline handlers exposed to ethyl gasoline*—Continued

1	552	591	598	615	634	703	711	715	723	736	740	760
2	0	0	0	0	2	0	0	0	1	0	2	0
3	3	1	2	1	3	2	1	1	4	1	4	1
4	65	23	53	30	22	58	23	39	30	63	28	29
5	66	68	73	69	68½	67	64	68	76	67¼	66¾	75
6	164	142	168	127	160	152	116	192	150	172	131	192
7	12	23½	23	16½	24½	16	14	22½	22	13	19½	19
8	8	18½	17½	9	18½	7	6½	17	16	11	11½	13
9	35½	39½	47½	30	49	28½	30½	43	42	24½	31½	42½
10	25½	30	31½	15	34½	14½	26	28	27½	18½	26	32
11	12	22	24	17	28	16	16	26	21	13	17	27
12	11	26	18	15	22	18	14	20	13	13	22	19
13	8	19	17	9	20	6	8	19	16	12	11	11
14	8	18	18	8	16	7	6½	16	16	11	13	16
15	134	136	112	122	135	112	126	142	102	122	144	120
16	59	54	44	47	55	38	48	47	34	54	66	40
17	81	54	44	62	32	48	58	75	44	68	52	64
18	15	15	20	15	15	15	15	15	15	15	15	15
19	0	0	0	+	0	0	0	0	0	0	0	0
20	Py	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	+	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	+	0	0	0	0	0	+	0	0
25	0	0	0	+	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0
29	+	+	+	0	0	0	0	+	0	+	+	0
30	0	0	+	+	0	0	0	0	0	+	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	+	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	+	0	0	0	0	0	0	0	0
40	G	G	G	P	G	G	F	G	F	G	G	G
41	88	92	95	80	100	92	85	96	94	90	80	Unk.
42	5.00	5.09	5.03	4.78	4.36	4.99	5.15	4.70	4.68	4.94	4.96	5.11
43	5	6	7	2	2	3	5	7	5	2	2	2
44	2.59	0.19	0.66	0.13	0.16	0.18	0.67	0.04	0.09	0.36	0.45	0.33
45	0.0392	0.0035	0.0031	0.0039	0.0039	0.0021	0.0054	0.0022	0.0043	0.0024	0.0026	0.0021
46	2.072	0.062	0.102	0.186	0.146	0.075	0.168	0.133	0.180	0.113	0.118	0.122

TABLE 10.—*Individual findings in Group D: Garage workers and gasoline handlers exposed to ethyl gasoline*—Continued

1	795	810	835	847	858	865	875	877	914	959	972	988
2	1	0	2	0	0	0	1	1	0	2	0	0
3	4	2	2	4	2	4	1	3	4	3	2	3
4	70	30	25	64	53	49	23	55	44	46	32	26
5	64¾	73½	67	70½	67	66	69¾	66	64	65	64	72¼
6	112	239	194	210	181	180	159	148	130	130	189	164
7	14	21½	22	16½	23½	19	22	16	14½	16½	17	32
8	12	14	13½	13	13	13½	13½	5	9¾	13½	14	19
9	23½	51½	33	34½	36	43½	32	23	22½	38	42	56
10	19½	34	25	21	23½	24	25	9	16	27	25½	29
11	14	24	24	15	24	20	22	18	16	18	18	29
12	13	18	19	18	23	16	22	15	12	16	16	33
13	12	14	14	11	15	17	14	5	9½	13	16	21
14	13	13	13	16	11	11	12	4	10	14	12	18
15	150	145	122	142	146	162	105	152	144	160	125	160
16	60	55	50	54	51	68	43	54	58	92	45	95
17	130	60	58	60	68	64	48	54	65	82	60	120
18	25	15	15	15	20	30	20	15	15	15	15	15
19	0	0	0	0	0	0	0	+	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	+	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	+	0	+	0	0
29	+	+	0	+	0	+	0	+	0	+	+	+
30	0	0	0	0	0	0	+	+	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	+	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	+	0	0	0	0
37	0	0	0	0	0	0	0	+	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	P	G	G	G	G	G	G	G	G	F	G	G
41	80	95	93	93	88	94	92	92	95	96	92	92
42	4.98	5.07	5.02	5.08	4.76	4.99	5.12	4.90	4.83	5.28	4.73	4.94
43	2	2	6	2	5	5	5	2	2	6	2	5
44	0.72	0.63	0.24	0.00	0.20	0.06	0.41	0.47	0.33	0.45	-------	0.60
45	0.0063	0.0044	0.0035	0.0000	0.0025	0.0006	0.0108	0.0048	0.0025	0.0031	-------	0.0098
46	0.277	0.098	0.109	0.000	0.154	0.041	0.456	0.127	0.127	0.145	-------	0.316

TABLE 11.—*Individual findings in Group E: Persons exposed to lead dusts .*

1. Case number	2	8	15	31	50	64	76	84	108
2. Other lead [1]	SS	M	SS	Sl	Sl	SS	S	Sl	Sl
3. Ethyl lead [2]	0	0	0	0	0	0	0	0	0
4. Age	30	31	53	26	27	28	42	25	31
5. Height, in inches	70	64½	68	70	67½	64	68½	69	65½
6. Weight in pounds	144	154	160	136	123	129	140	132	139
7. Wrist extensors [3]	------	20	12½	17½	17	18	16	21½	13½
8. Finger extensors [3]	------	14	8¾	12	12½	11½	10	13	8¾
9. Wrist flexors [3]	------	40	27	41	29	40	28	34½	23½
10. Finger flexors [3]	------	30½	19	19½	22½	25	18	28½	16
11. Right-wrist extensors [3]	------	20	14	20	17	18	18	24	16
12. Left-wrist extensors [3]	------	20	11	16	17	18	14	18	13
13. Right-finger extensors [3]	------	14	10	11	14	11	11	15	11
14. Left-finger extensors [3]	------	16	8½	12	11	13	10	12	6
15. Systolic pressure (sitting)	130	128	120	122	109	128	120	128	116
16. Pulse pressure (sitting)	64	36	40	60	53	50	54	58	56
17. Pulse pressure (recumbent)	64	46	48	73	61	57	66	69	64
18. Vision [4]	30	20	* 100	15	10	15	13	13	15
19. General health [5]	0	0	0	0	0	0	0	0	0
20. Color [5]	P	P	0	0	0	0	P	0	0
21. Rate of tiring [5]	0	0	+	0	0	0	0	0	0
22. Muscle strength [5]	0	0	+	0	0	0	0	0	0
23. Pains in joints [5]	+	0	+	0	0	0	0	0	0
24. Constipation [5]	+	0	0	0	0	0	+	0	0
25. Appetite [5]	+	0	+	0	0	+	+	0	0
26. Nausea [5]	0	0	+	0	0	0	0	0	0
27. Abdominal pains [5]	+	0	+	0	0	0	0	0	0
28. Taste [5]	+	0	+	+	+	0	+	+	0
29. Tongue coated [5]	+	0	0	+	0	0	+	+	+
30. Pyorrhea [5]	+	0	+	0	0	0	0	0	0
31. Lead line [5]	0	0	+	+	0	+	0	0	0
32. Headache [5]	+	0	0	0	+	+	+	0	0
33. Numbness [5]	+	0	+	0	0	0	0	0	0
34. Other paræsthesias [5]	0	0	0	0	0	0	0	0	0
35. Twitchings [5]	+	0	+	0	0	0	0	0	0
36. Impaired sensation [5]	0	0	0	0	0	0	0	0	0
37. Tremors [5]	0	+	+	+	+	0	0	0	0
38. Patellar reflex [5]	0	0	0	0	0	0	0	0	0
39. Achilles reflex [5]	0	0	0	0	0	0	0	0	0
40. Nutrition [6]	F	G	G	F	F	G	F	F	G
41. Hemoglobin percentage	Unk.	90	65	95	94	80	85	83	Unk.
42. Red cells [7]	Unk.	4.71	3.90	5.01	4.83	4.86	4.80	4.64	4.73
43. Stippling [8]	6	7	9	2	7	9	5	9	9
44. Milligrams lead in feces	1.53	0.49	2.61	3.11	------	------	------	0.24	5.04
45. Milligram lead per gram feces	0.0235	0.0047	0.0318	0.0179	------	------	------	0.0100	0.0560
46. Milligrams lead per gram ash	7.650	0.156	1.977	0.478	------	------	------	0.343	2.290

*Uses glasses for reading. Visual acuity without glasses is tabulated.

See notes on p. 45.

TABLE 11.—*Individual findings in Group E: Persons exposed to lead dusts*—Con.

	121	123	141	150	164	187	214	221	253	276	281	307	315
2	Sl	M	Sl	SS	M	SS	Sl	SS	SS	SS	SS	Sl	SS
3	0	0	0	0	0	0	0	0	0	0	0	0	1
4	23	20	24	33	21	39	45	18	43	20	38	25	18
5	67	66½	69½	68½	71	61	65	66	63½	62¾	65	66	64¾
6	126	127	126	152	140	118	156	179	130	102	130	118	121
7	18	21¼	19½	20	17	8	17	13	16	13½	20	11	15½
8	15	10½	11	14	10½	5½	11	10	8	7¼	13	8	12
9	33	33	34	44	29	13	38½	19	33	32½	34	19½	30
10	26½	20½	22½	40½	16	9¼	23½	17½	18	16½	25	12	22½
11	19	22	22	24	18	8	16	15	17	16	20	11	15
12	17	21	19	20	14	8	18	12	16	13	20	10	17
13	16	11	12	16	10	5	10	12	7½	8	14	8	11
14	15	9	10	14	11	5¾	11	10	8½	6½	13	8	13
15	120	136	110	128	135	106	132	134	145	108	152	121	116
16	68	68	45	56	65	31	52	58	67	30	62	58	51
17	94	80	58	65	82	42	60	77	65	40	71	73	68
18	15	13	15	50	15	Unk.	15	15	15	Unk.	15	15	15
19	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	P	0	0	C	0	0	P	C	0	0	0
21	0	0	0	0	0	+	0	0	0	0	0	0	0
22	0	0	0	0	0	+	0	0	+	0	0	+	+
23	0	0	0	0	0	0	0	0	0	0	0	0	+
24	0	0	0	+	+	0	0	0	0	0	0	0	0
25	0	0	0	+	0	0	0	+	+	+	0	+	0
26	0	0	0	+	0	0	0	0	+	+	0	+	0
27	0	0	0	+	0	+	0	+	+	+	0	+	+
28	0	0	0	+	0	+	0	0	+	+	0	0	0
29	+	+	0	+	0	+	+	+	+	+	+	+	+
30	0	0	0	0	0	+	+	0	0	+	0	0	0
31	0	0	+	+	0	+	0	0	+	+	0	0	+
32	0	0	0	0	0	+	0	0	0	+	0	+	0
33	0	0	0	0	0	+	+	0	0	0	0	+	0
34	0	0	0	+	0	+	0	0	0	0	0	+	0
35	0	0	0	0	0	+	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	+	0	0	0	+	+	0	+	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
40	F	F	F	F	F	G	G	G	G	F	F	F	G
41	Unk.	90	80	60	100	82	Unk.	85	65	85	82	84	Unk.
42	Unk.	5.00	5.01	3.69	5.16	4.23	4.82	4.82	4.06	5.00	4.59	4.60	Unk.
43	6	5	7	9	6	9	7	9	9	9	8	6	9
44	0.85	0.40	------	12.17	0.79	9.98	0.62	------	------	------	------	4.38	------
45	0.0207	0.0048	------	0.0360	0.0110	0.2041	0.0097	------	------	------	------	0.0456	------
46	0.500	0.222	------	2.213	0.161	6.048	0.496	------	------	------	------	0.984	------

Item numbered at on p. 62.

TABLE 11.—*Individual findings in Group E: Persons exposed to lead dust*—Con.

1	323	324	330	360	366	370	389	403	435	454	470	480	485
2	SS	SS	M	SS	S	SS	Sl	Sl	S	SS	S	S	SS
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	23	28	24	29	24	44	21	23	24	24	23	17	37
5	65½	70½	66	62¾	65½	61½	70	67	65	69	63½	60	66
6	145	141	132	145	113	119	163	130	138	196	131	116	150
7	22	19	17	22½	14	-------	29	19	20½	19½	18	18½	18
8	10½	12	12½	12	9	-------	13½	9	13½	11	10½	9	7½
9	42	32	26	36½	24½	-------	52½	42	45½	37	31	31	38
10	34	21	23½	24	16	-------	38½	24	34	23	17	20½	29½
11	24	22	18	23	16	-------	31	22	23	22	15	22	18
12	21	18	16	22	10	-------	26	19	19	17	20	16	18
13	9	12	15	13	10	-------	15	10	16	11	12	9	9
14	12	12	12	11	9	-------	13	8	12	11	10	9	6½
15	140	140	115	130	122	142	145	116	122	126	116	110	135
16	75	54	43	70	54	52	83	52	52	28	32	64	49
17	82	68	38	90	70	58	94	60	60	61	37	72	58
18	15	15	13	15	15	15	15	15	15	15	15	15	20
19	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	P	0	P	0	0	0	0	C	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	+	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	+	0	0	0	0	0
24	0	+	0	0	0	+	+	0	0	0	+	0	0
25	+	0	0	0	0	0	0	0	0	0	0	0	+
26	+	0	0	0	0	0	0	0	0	0	0	0	0
27	+	0	0	+	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	+
29	0	+	0	+	+	0	+	0	0	+	+	0	+
30	0	0	0	0	0	+	0	0	0	0	0	0	0
31	0	+	0	0	0	+	0	0	0	0	0	0	+
32	0	0	0	+	0	0	0	0	0	0	0	0	0
33	0	0	0	+	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	+	0	0	0	0	0
35	+	0	0	0	0	0	0	0	0	0	0	+	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	+	+	0	+	0	+	0	0	0	0	0	+
38	0	+	0	0	0	Unk.	0	0	0	0	0	0	0
39	0	+	0	0	0	Unk.	0	+	0	0	0	0	0
40	G	F	F	G	F	F	G	F	G	G	F	G	G
41	85	75	90	Unk.	87	80	92	92	90	94	85	94	88
42	4.99	4.50	5.02	Unk.	4.98	3.97	5.10	5.04	4.28	5.05	4.99	5.04	5.02
43	9	6	2	8	3	9	8	8	8	8	9	5	9
44	3.29	1.21	0.40	2.95	-------	5.21	0.71	0.59	-------	0.62	-------	-------	-------
45	0.0173	0.0367	0.0076	0.0670	-------	0.0334	0.0158	0.0081	-------	0.0061	-------	-------	-------
46	0.530	1.210	0.357	2.950	-------	1.160	0.710	0.211	-------	0.326	-------	-------	-------

TABLE 11.—*Individual findings in Group E: Persons exposed to lead dust*—Con.

1	499	529	542	555	560	565	606	656	674	679	693	700	732
2	SS	Sl	Sl	Sl	Sl	Sl	Sl	SS	SS	S	S	Sl	SS
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	52	40	18	26	30	37	44	41	23	18	18	45	34
5	69	66½	65	66	70	63	69½	66	64	67¾	68	60½	65
6	217	140	128	151	160	155	162	191	120	125	133	128	164
7	25	16½	17½	20	18½	21½	18½	19½	17	17	18	16½	9½
8	17	11½	11	12	11½	16	14	13	13½	13½	11	9	5
9	42	29½	33	40	43	44	38½	34	35	37	30	30	19½
10	29	21	23	26½	26½	29	30	27½	20	28	22	20½	17
11	27	16	16	21	22	21	20	24	19	19	20	19	8
12	23	18	18	19	16	22	17	15	15	16	17	14	12
13	16	10	11	12	15	14	14	15	15	15	12	9	5¼
14	19	12	11	12	11	17	14	13	12	12	10	8	4¼
15	138	133	127	120	135	140	130	130	152	130	120	126	122
16	43	65	82	52	55	45	80	45	90	72	48	28	27
17	53	78	85	52	54	50	75	64	106	88	64	40	43
18	25	15	15	15	15	15	30	15	15	15	15	15	15
19	0	0	0	0	0	0	0	0	0	0	0	0	+
20	C	0	0	0	0	0	0	0	0	0	P	0	0
21	0	0	0	0	0	0	0	+	+	0	0	0	+
22	0	0	0	0	0	0	0	0	0	0	0	0	+
23	0	0	0	0	0	0	0	0	+	0	0	0	0
24	0	0	+	0	0	0	0	0	0	0	0	0	+
25	0	0	0	+	0	0	0	0	0	0	0	0	+
26	0	0	0	0	0	0	0	+	0	0	0	+	+
27	0	0	0	0	0	0	0	+	0	0	0	0	+
28	0	0	0	0	0	0	+	0	+	+	0	0	0
29	+	0	+	+	+	+	+	0	0	+	+	+	+
30	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	+	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	+	+	0	0	+	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	+	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	+	0	0	0	0	+	0	+	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0
39	+	0	0	0	0	0	0	0	0	0	0	0	0
40	G	F	F	G	G	G	G	G	F	F	F	G	G
41	88	85	90	Unk.	95	92	70	75	Unk.	Unk.	80	85	90
42	4.83	5.04	4.89	Unk.	5.03	4.10	3.64	4.87	Unk.	Unk.	4.58	4.87	4.98
43	6	9	9	2	6	6	9	7	8	8	8	7	7
44	4.61	2.04	------	1.06	0.57	0.43	6.03	1.57	------	4.44	------	0.81	0.40
45	0.0297	0.0392	------	0.0147	0.0061	0.0148	0.0413	0.0075	------	0.0430	------	0.0057	0.0029
46	1.356	1.020	------	0.321	0.285	0.506	2.620	0.378	------	1.430	------	0.540	0.148

TABLE 11.—*Individual findings in Group E: Persons exposed to lead dust*—Con.

1	764	780	805	813	820	828	873	887	898	910	950	952	985
2	Sl	Sl	S	SS	Sl	Sl	SS	SS	Sl	S	Sl	Sl	Sl
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	26	36	15	19	21	51	49	24	19	21	48	27	34
5	61	67	63½	65	64½	66½	69½	67½	68	67	68½	73	70½
6	106	157	112	143	156	157	150	142	132	141	148	146	147
7	16	18	12	22½	20½	14½	23	19½	18½	15½	16	16	17
8	10	9¼	7¼	12	16	10½	13	16	12	7¾	Unk.	9½	11½
9	25½	37½	18	48½	33½	31½	50	50	37½	27	46	34½	32½
10	17½	22½	15½	30	25½	23	33	35½	24	18	Unk.	22	26
11	17	23	15	26	23	20	26	21	19	16	16	20	21
12	15	15	11	18	20	12	20	18	18	15	16	14	15
13	10	9	8	13	16	12	15	18	12	8	Unk.	11	12
14	9	9½	7	11	16	10	12	16	12	7½	Unk.	8	11
15	116	142	140	116	126	146	120	146	108	120	124	105	120
16	54	52	65	61	40	76	30	70	46	65	54	51	62
17	70	51	89	79	56	84	44	87	47	74	53	57	74
18	15	15	15	15	15	60	Unk.	15	15	15	20	20	15
19	0	0	0	+	0	0	+	0	0	0	0	0	0
20	P	0	P	C	0	P	C	0	0	0	0	P	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0
24	+	0	0	+	0	0	0	0	+	0	0	0	0
25	0	0	0	+	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	+	0	0	0	0	0	0
27	0	0	0	+	0	0	0	0	0	0	0	0	0
28	+	0	0	0	0	0	0	0	0	+	0	0	0
29	0	+	+	+	+	+	+	0	0	+	0	+	+
30	0	0	0	0	0	+	0	0	0	0	0	0	0
31	+	0	0	+	0	0	0	0	0	0	0	0	0
32	+	0	0	+	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	+	0	0	0	0	0	0	0	0	0	+
35	0	0	0	0	0	0	0	0	+	0	0	0	+
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	+	0	0	0	0	0	0
39	0	+	0	0	0	0	0	0	0	0	0	0	0
40	F	G	F	G	G	G	F	G	F	G	F	G	F
41	90	90	88	80	80	90	70	80	95	90	85	Unk.	91
42	4.98	4.57	4.87	3.95	4.45	4.97	2.75	4.29	4.81	5.03	4.88	Unk.	4.62
43	8	5	9	8	7	8	9	5	8	8	8	8	5
44	0.97	------	------	3.53	0.64	1.14	2.50	1.69	0.00	------	3.80	1.95	2.06
45	0.0103	------	------	0.0929	0.0066	0.0148	0.0781	0.0245	0.0000	------	0.0170	0.0111	0.0687
46	0.539	------	------	2.401	0.366	0.814	2.381	0.735	0.000	------	0.655	0.385	0.624

TABLE 12.—*Distribution of persons according to ratio of weight in pounds to height in inches*

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
1.25-1.49		1				
1.50-1.74		3		4	5	3
1.75-1.99	25	36	33	14	33	29
2.00-2.24	33	34	43	30	31	33
2.25-2.49	17	14	5	25	23	18
2.50-2.74	14	9	10	12	3	9
2.75-2.99	8	3	5	12	3	6
3.00-3.24			5		2	1
3.25-3.49	3			4		1
Total	100	100	100	100	100	100

NUMBER OF PERSONS

1.25-1.49		1				1
1.50-1.74		2		2	3	7
1.75-1.99	9	28	7	8	20	72
2.00-2.24	12	26	9	17	19	83
2.25-2.49	6	11	1	14	14	46
2.50-2.74	5	7	2	7	2	23
2.75-2.99	3	2	1	7	2	15
3.00-3.24			1		1	2
3.25-3.49	1			2		3
Total	36	77	21	57	61	252

TABLE 13.—*Distribution of persons according to nutrition*

PERCENTAGE

Nutritional state	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
Good	61	52	71	70	51	59
Fair	36	47	29	25	49	39
Poor	3	1		5		2
Total	100	100	100	100	100	100

NUMBER OF PERSONS IN EACH NUTRITION GROUP

Good	22	40	15	40	31	148
Fair	13	36	6	14	30	99
Poor	1	1		3		5
Total	36	77	21	57	61	252

TABLE 14.—*Distribution of persons according to loss from highest w ight (own estimate)*

PERCENTAGE

Weight loss in pounds	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0–4	17	19	10	14	10	20
5–9	33	36	52	30	17	33
10–14	25	21	10	25	12	21
15–19	17	12	19	9	2	12
20–24	3	6		11	5	6
25–29	6		5	3		2
30–34		4	5	3	3	3
35–39		1		2		1
40–44						
45–49				3		1
50 and over					2	1
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0–4	6	15	2	8	18	49
5–9	12	28	11	17	16	84
10–14	9	16	2	14	13	54
15–19	6	9	4	5	7	31
20–24	1	5		6	3	15
25–29	2		1	2		5
30–34		3	1	2	2	8
35–39		1		1		2
40–44						
45–49				2		2
50 and over					1	1
Total	36	77	21	[1] 57	[1] 60	[1] 251

[1] Exclusive of 1 unknown.

TABLE 15.—*Distribution of persons according to systolic blood pressure, sitting*

PERCENTAGE

Systolic pressure in millimeters of mercury	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
105	----	5	----	2	----	2
105-114	6	16	----	12	11	11
115-124	25	31	43	26	34	31
125-134	8	30	38	14	26	23
135-144	36	12	14	25	18	20
145-154	14	3	5	12	10	8
155-164	6	3	----	5	----	3
165 and over	6	1	----	4	----	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

105	----	4	----	1	----	5
105-114	2	12	----	7	7	28
115-124	9	24	9	15	21	78
125-134	3	23	8	8	16	58
135-144	13	9	3	14	11	50
145-154	5	2	1	7	6	21
155-164	2	2	----	3	----	7
165 and over	2	1	----	2	----	5
Total	36	77	21	57	61	252

MEDIAN AGE OF PERSONS

	37	31	26	39	26	32

TABLE 16.—*Distribution of persons according to systolic blood pressure, sitting, by deviations from normal at each age*

PERCENTAGE

Negative or positive deviation in millimeters of mercury	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
More than −25	3	1	----------	9	----------	3
−25 to −16	8	18	----------	12	8	12
−15 to −6	19	19	24	21	26	22
−5 to 4	14	32	48	21	34	29
5 to 14	36	16	19	16	20	20
15 to 24	11	10	5	14	10	11
25 and more	8	3	5	7	2	4
Total	100	100	100	100	100	100

NUMBER OF PERSONS

More than −25	1	1	----------	5	----------	7
−25 to −16	3	14	----------	7	5	29
−15 to −6	7	15	5	12	16	55
−5 to 4	5	25	10	12	21	73
5 to 14	13	12	4	9	12	50
15 to 24	4	8	1	8	6	27
25 and more	3	2	1	4	1	11
Total	36	77	21	57	61	252

NOTE.—The normal blood pressures used in calculating these figures are derived from the examination of over 10,000 persons in industry and are published in Public Health Bulletin No. 162 (1926). Many of the blood-pressure readings on which these normal values are based were taken by the same physician who took the blood pressures throughout this investigation.

TABLE 17.—*Distribution of persons according to pulse pressure, sitting*

PERCENTAGE

Pulse pressure in millimeters of mercury	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
25-34	3	19	5	2	12	10
35-44	36	39	33	25	8	27
45-54	25	23	19	33	34	28
55-64	19	12	24	16	20	17
65-74	14	5	19	14	16	12
75-84		1		5	8	4
85 and over	3			5	1	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

25-34	1	15	1	1	7	25
35-44	13	30	7	14	5	69
45-54	9	18	4	19	21	71
55-64	7	9	5	9	12	42
65-74	5	4	4	8	10	31
75-84		1		3	5	9
85 and over	1			3	1	5
Total	36	77	21	57	61	252

TABLE 18.—*Distribution of persons according to pulse pressure, recumbent*

PERCENTAGE

Pulse pressure in millimeters of mercury	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
25–34	3	4	5	4	----------	3
35–44	14	17	19	9	12	13
45–54	22	29	19	23	15	22
55–64	31	34	24	26	25	29
65–74	11	9	24	16	23	15
75–84	11	8	5	12	13	10
85–94	3	----------	5	5	11	5
95 and over	6	----------	----------	5	2	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

25–34	1	3	1	2	----------	7
35–44	5	13	4	5	7	34
45–54	8	22	4	13	9	56
55–64	11	26	5	15	15	72
65–74	4	7	5	9	14	39
75–84	4	6	1	7	8	26
85–94	1	----------	1	3	7	12
95 and over	2	----------	----------	3	1	6
Total	36	77	21	57	61	252

TABLE 19.—*Distribution of persons according to excess of pulse pressure when sitting over pulse pressure when recumbent*

PERCENTAGE

Negative or positive excess, in millimeters of mercury	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
−35 and more				2		(1)
−34 to −25	8	7		7	4	6
−24 to −15	22	27	14	19	26	23
−14 to −5	31	36	48	37	54	41
−4 to 4	28	23	33	19	13	21
5 to 14	11	4	5	12	3	7
15 to 24		1		4		1
25 to 34		1				(1)
35 to 44						
Total	100	100	100	100	100	100

NUMBER OF PERSONS

−35 and more				1		1
−34 to −25	3	5		4	2	14
−24 to −15	8	21	3	11	16	59
−14 to −5	11	28	10	21	33	103
−4 to 4	10	18	7	11	8	54
5 to 14	4	3	1	7	2	17
15 to 24		1		2		3
25 to 34		1				1
35 to 44						
Total	36	77	21	57	61	252

[1] Less than 0.5 per cent.

TABLE 20.—*Distribution of persons according to hemoglobin ratings (Dare scale)*

PERCENTAGE

Hemoglobin percentage, Dare scale	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
98–100	14	8	5	5	2	7
93–97	29	28	37	36	12	27
88–92	40	43	53	37	33	40
83–87	15	7	5	9	21	11
78–82	3	10		13	18	10
73–77		3			4	2
68–72					4	1
Under 68		1			6	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

98–100	5	6	1	3	1	16
93–97	10	21	7	20	6	64
88–92	14	32	10	21	17	94
83–87	5	5	1	5	11	27
78–82	1	8		7	9	25
73–77		2			2	4
68–72					2	2
Under 68		1			3	4
Total	[1] 35	[2] 75	[3] 19	[1] 56	[3] 51	[4] 236

[1] One unknown. [2] Two unknown. [3] Ten unknown. [4] Sixteen unknown.

TABLE 21.—*Distribution of persons according to red blood cell count (in millions)*

PERCENTAGE

Millions red cells per cubic millimeter	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
5.75–5.99		1				
5.50–5.74	6	1	5			2
5.25–5.49	6	5	5	3		4
5.00–5.24	36	36	29	35	26	33
4.75–4.99	28	39	38	46	34	38
4.50–4.74	22	9	19	9	17	14
4.25–4.49		4		4	6	3
4.00–4.24	3	4	5	2	6	4
3.75–3.99					6	1
3.50–3.74				2	4	1
3.50					2	
Total	100	100	100	100	100	100

NUMBER OF PERSONS

5.75–5.99		1				1
5.50–5.74	2	1	1			4
5.25–5.49	2	4	1	2		9
5.00–5.24	13	28	6	20	14	81
4.75–4.99	10	30	8	26	18	92
4.50–4.74	8	7	4	5	9	33
4.25–4.49		3		2	3	8
4.00–4.24	1	3	1	1	3	9
3.75–3.99					3	3
3.50–3.74				1	2	3
3.50					1	1
Total	36	77	21	57	[1] 53	[1] 244

[1] Eight unknown.

TABLE 22.—*Distribution of persons according to vision (Snellen test of better eye)* [1]

PERCENTAGE

Visual Acuity	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
15/15 or better	81	90	86	74	83	83
15/20	11	4	14	9	7	8
15/25	3			7	2	2
15/30		6		9	3	5
15/40 or worse	6			2	5	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

15/15 or better	29	69	18	42	48	206
15/20	4	3	3	5	4	19
15/25	1			4	1	6
15/30		5		5	2	12
15/40 or worse	2			1	3	6
Total	36	77	21	57	[2] 58	[2] 249

[1] In case glasses were worn, corrected vision was determined.

[2] Unknown, 3.

TABLE 23.—*General phenomena*

[Percentages and numbers indicate deviations from normal similar to those found in some cases of lead poisoning] [1]

PERCENTAGE

	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
General health		3		3	5	3
Color	11	1	10	7	20	9
Rate of tiring (subjective)	3	1	10	3	8	4
Muscle strength (subjective)	3			5	11	4
Pains in joints	19	14	5	3	8	10

NUMBER OF CASES

General health		2		2	3	7
Color	[2] 4	1	2	4	12	23
Rate of tiring (subjective)	1	1	2	2	5	11
Muscle strength (subjective)	1			3	7	11
Pains in joints	7	11	1	2	5	26

NUMBER OF PERSONS

	[3] 36	77	21	57	61	[3] 252

[1] See Table 14 for loss of weight (subjective). [2] One unknown [3] One unknown for color.

TABLE 24.—*Phenomena of digestive system*

[Percentages and numbers indicate deviations from normal similar to those found in some cases of lead poisoning]

PERCENTAGE

	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
Subjective:						
Constipation	22	21	14	9	21	18
Appetite	3	3	----------	4	23	8
Nausea	3	10	10	4	16	9
Abdominal pains	6	13	10	5	23	12
Taste	17	23	19	11	26	20
Objective:						
Tongue (coated)	53	44	57	51	69	54
Pyorrhea	33	8	5	23	11	15
Lead line	----------	----------	----------	----------	25	6

NUMBER OF CASES

Subjective:						
Constipation	8	16	3	5	13	45
Appetite	1	[1]2	----------	2	14	[1]19
Nausea	1	8	2	2	10	23
Abdominal pains	2	10	2	3	14	31
Taste	6	18	4	6	16	50
Objective:						
Tongue (coated)	19	34	12	29	42	136
Pyorrhea	12	6	1	13	7	39
Lead line	----------	----------	----------	----------	15	15

NUMBER OF PERSONS

	36	[1]77	21	57	61	[1]252

[1] One unknown for appetite.

TABLE 25.—*Nervous phenomena*

[Percentages and numbers indicate deviations from normal similar to those found in some cases of lead poisoning]

PERCENTAGE

	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
Subjective:						
Headache	14	8	29	9	16	13
Numbness	6		5	2	15	5
Other paræsthesias		3	5	5	10	5
Twitchings	6	10	19	7	13	10
Objective:						
Impaired sensation (pain, touch, heat, cold)			5	4		1
Tremors	8	4	5		26	9
Patellar reflex	3	3			3	2
Achilles reflex	3	1		4	7	3

NUMBER OF CASES

Subjective:						
Headache	5	6	6	5	10	32
Numbness	2		1	1	9	13
Other paræsthesias		2	1	3	6	12
Twitchings	2	8	4	4	8	26
Objective:						
Impaired sensation (pain, touch, heat, cold)			1	2		3
Tremors	3	3	1		16	23
Patellar reflex	1	2			[1] 2	5
Achilles reflex	1	1		2	[1] 4	8

NUMBER OF PERSONS

	36	77	21	57	[1] 61	[2] 252

[1] Unknown for 1 person.

[2] One unknown each for patellar reflex and Achilles reflex.

TABLE 26.—*Medians of strength test ratios*

Ratio (as to strength) of—	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)
Wrist extensors to weight	0.117	0.126	0.131	0.125	0.129
Finger extensors to weight	.072	.065	.085	.083	.083
Wrist extensors to wrist flexors	.52	.56	.53	.56	.52
Finger extensors to finger flexors	.45	.40	.45	.54	.48
Right-wrist extensors to left-wrist extensors	1.11	1.11	1.06	1.13	1.17
Right-finger extensors to left-finger extensors	1.00	.94	1.08	1.08	1.12

TABLE 27.—*Distribution of persons according to ratio of strength of wrist extensors to weight*

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0.055–0.064	3				2	1
0.065–0.074	6			2	3	2
0.075–0.084	3	3		5	2	3
0.085–0.094	6	1		7	3	4
0.095–0.104	22	5	19	5	5	9
0.105–0.114	8	11		14	14	11
0.115–0.124	8	23	19	14	15	17
0.125–0.134	17	27	19	26	15	22
0.135–0.144	11	11	5	9	20	12
0.145–0.154	8	11	14	12	10	11
0.155–0.164	6	5	10		8	5
0.165–0.174	3	1	10	2		2
0.175 and over		1	5	4	2	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0.055–0.064	1				1	2
0.065–0.074	2			1	2	5
0.075–0.084	1	2		3	1	7
0.085–0.094	2	1		4	2	9
0.095–0.104	8	4	4	3	3	22
0.105–0.114	3	8		8	8	27
0.115–0.124	3	17	4	8	9	41
0.125–0.134	6	20	4	15	9	54
0.135–0.144	4	8	1	5	12	30
0.145–0.154	3	8	3	7	6	27
0.155–0.164	2	4	2		5	13
0.165–0.174	1	1	2	1		5
0.175 and over		1	1	2	1	5
Total	36	[1] 74	21	57	[2] 59	[3] 247

[1] Exclusive of 3 unknown. [2] Exclusive of 2 unknown. [3] Exclusive of 5 unknown.

TABLE 28.—*Distribution of persons according to ratio of strength of finger extensors to weight*

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0.025–0.034	3		5	2	2	2
0.035–0.044	8	8	5			4
0.045–0.054	6	25	14	9	3	12
0.055–0.064	19	18		14	12	14
0.065–0.074	19	22		17	21	18
0.075–0.084	14	10	24	9	22	14
0.085–0.094	6	5	19	21	19	13
0.095–0.104	8	11	10	14	14	12
0.105–0.114	8	1	5	7	5	5
0.115 and over	8		19	7	2	5
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0.025–0.034	1		1	1	1	4
0.035–0.044	3	6	1			10
0.045–0.054	2	18	3	5	2	30
0.055–0.064	7	13		8	7	35
0.065–0.074	7	16		10	12	45
0.075–0.084	5	7	5	5	13	35
0.085–0.094	2	4	4	12	11	33
0.095–0.104	3	8	2	8	8	29
0.105–0.114	3	1	1	4	3	12
0.115 and over	3		4	4	1	12
Total	36	[1] 73	21	57	[2] 58	[3] 245

[1] Exclusive of 4 unknown. [2] Exclusive of 3 unknown. [3] Exclusive of 7 unknown.

TABLE 29.—*Distribution of persons according to ratio of strength of wrist extensors to that of wrist flexors*

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0.33–0.37				2	2	1
0.38–0.42	11	3	14	4	3	5
0.43–0.47	11	15	10	12	25	16
0.48–0.52	28	18	23	19	20	21
0.53–0.57	11	26	19	23	20	21
0.58–0.62	25	19	10	21	20	20
0.63–0.67	8	8	5	12	7	9
0.68–0.72	3	7	14	7	2	6
0.73 and over	3	4	5			2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0.33–0.37				1	1	2
0.38–0.42	4	2	3	2	2	13
0.43–0.47	4	11	2	7	15	39
0.48–0.52	10	13	5	11	12	51
0.53–0.57	4	19	4	13	12	52
0.58–0.62	9	14	2	12	12	49
0.63–0.67	3	6	1	7	4	21
0.68–0.72	1	5	3	4	1	14
0.73 and over	1	3	1			5
Total	36	[1] 73	21	57	[2] 59	[3] 246

[1] Exclusive of 4 unknown. [2] Exclusive of 2 unknown. [3] Exclusive of 6 unknown.

TABLE 30.—*Distribution of persons according to the ratio of strength of finger extensors to that of finger flexors*

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0.23		1				0
0.23–0.27	3	4	5	2	2	3
0.28–0.32	6	19	5	5	3	9
0.33–0.37	14	12	19	2	3	9
0.38–0.42	25	26	10	9	9	16
0.43–0.47	8	15	24	16	38	19
0.48–0.52	22	10	14	9	15	13
0.53–0.57	8	3	10	19	17	11
0.58–0.62	11	8	5	25	10	13
0.63–0.67	3	1	10	9	5	5
0.68 and over				5	2	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0.23		1				1
0.23–0.27	1	3	1	1	1	7
0.28–0.32	2	14	1	3	2	22
0.33–0.37	5	9	4	1	2	21
0.38–0.42	9	19	2	5	5	40
0.43–0.47	3	11	5	9	19	47
0.48–0.52	8	7	3	5	9	32
0.53–0.57	3	2	2	11	10	28
0.58–0.62	4	6	1	14	6	31
0.63–0.67	1	1	2	5	3	12
0.68 and over				3	1	4
Total	36	[1] 73	21	57	[2] 58	[3] 245

[1] Exclusive of 4 unknown. [2] Exclusive of 3 unknown. [3] Exclusive of 7 unknown.

TABLE 31.—*Distribution of persons according to ratio of strength of right-wrist extensors to that of left-wrist extensors* [1]

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0.65–0.74		3		2	2	2
0.75–0.84	8	4	5	5	2	5
0.85–0.94	8	12	10	9	7	9
0.95–1.04	17	12	24	21	14	16
1.05–1.14	25	26	29	18	19	22
1.15–1.24	14	19	14	19	24	19
1.25–1.34	8	16	14	19	15	15
1.35–1.44	11	4	5	4	12	7
1.45–1.54		1		2	2	1
1.55–1.64	3			2	3	2
1.65–1.74					2	0
1.75 and over	6	1				1
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0.65–0.74		2		1	1	4
0.75–0.84	3	3	1	3	1	11
0.85–0.94	3	9	2	5	4	23
0.95–1.04	6	9	5	12	8	40
1.05–1.14	9	19	6	10	11	55
1.15–1.24	5	14	3	11	14	47
1.25–1.34	3	12	3	11	9	38
1.35–1.44	4	3	1	2	7	17
1.45–1.54		1		1	1	3
1.55–1.64	1			1	2	4
1.65–1.74					1	1
1.75 and over	2	1				3
Total	36	[2] 73	21	57	[3] 59	[4] 246

[1] In the case of left-handed persons the ratio of left-wrist extensor strength to right-wrist extensor strength is used.
[2] Exclusive of 4 unknown.
[3] Exclusive of 2 unknown.
[4] Exclusive of 6 unknown.

TABLE 32.—*Distribution of persons according to ratio of strength of right-finger extensors to strength of left-finger extensors* [1]

PERCENTAGE

Ratio	Users of automobiles		Garage workers and gasoline handlers		Persons exposed to relatively soluble lead dust	Total
	With no ethyl gasoline (A)	With ethyl gasoline (B)	Not exposed to ethyl gasoline (C)	Exposed to ethyl gasoline (D)	(E)	
0.45–0.54	3					0
0.55–0.64	11	5				3
0.65–0.74	14	8		5		6
0.75–0.84	6	15	10	7	7	9
0.85–0.94	11	24	5	16	14	16
0.95–1.04	17	18	19	16	17	17
1.05–1.14	19	12	24	23	21	19
1.15–1.24	8	5	29	18	21	14
1.25–1.34	11	8	5	12	14	11
1.35–1.44			5	2	5	2
1.45–1.54		1	5			0
1.55 and over		3		2	2	2
Total	100	100	100	100	100	100

NUMBER OF PERSONS

0.45–0.54	1					1
0.55–0.64	4	4				8
0.65–0.74	5	6		3		14
0.75–0.84	2	11	2	4	4	23
0.85–0.94	4	18	1	9	8	40
0.95–1.04	6	13	4	9	10	42
1.05–1.14	7	9	5	13	12	46
1.15–1.24	3	4	6	10	12	35
1.25–1.34	4	6	1	7	8	26
1.35–1.44			1	1	3	5
1.45–1.54		1	1			2
1.55 and over		2		1	1	4
Total	36	[3] 74	21	57	[3] 58	[3] 246

[1] In the case of left-handed persons the ratio of strength of left-finger extensors to that of right-finger extensors is used.
[2] Exclusive of 3 unknown.
[3] Exclusive of 6 unknown.

TABLE 33.—*Stippling of red blood cells, by exposure groups*

PERCENTAGE

Exposure groups	Stippled cells per 100,000 red cells								Total
	None	Very fine granules (questionable)		Definite stippling					
		1–3	Over 3	1–2	3–6	7–20	21–100	Over 100	
Car users:									
No ethyl gasoline (A)	75	11	3	6	------	3	3	------	100
Ethyl gasoline (B)	79	8	1	9	3	------	------	------	100
Garage and gasoline workers:									
No ethyl gasoline (C)	62	10	5	19	5	------	------	------	100
Ethyl gasoline (D)	51	4	------	28	9	9	------	------	100
Exposed to lead dusts (E)	5	2	------	10	13	13	26	31	100

NUMBER OF PERSONS

A	27	4	1	2	------	1	1	------	36
B	61	6	1	7	2	------	------	------	77
C	13	2	1	4	1	------	------	------	21
D	29	2	------	16	5	5	------	------	57
E	3	1	------	6	8	8	16	19	61
Total	133	15	3	35	16	14	17	19	252

TABLE 34.—*Stippling of red blood cells by subgroups of Group E (persons exposed to lead dusts)*

PERCENTAGE

Exposure to lead dusts	Stippled cells per 100,000 red cells								Total
	None	Very fine granules (questionable)		Definite stippling					
		1–3	Over 3	1–2	3–6	7–20	21–100	Over 100	
Slight, present exposure (Subgroup M)	25	------	------	25	25	25	------	------	100
Moderate, present (Subgroup SI)	8	------	------	8	16	20	28	20	100
Severe, present, 1 month or less (Subgroup S)	------	11	------	22	------	------	44	22	100
Severe, present, more than 1 month (Subgroup SS)	------	------	------	4	13	9	22	52	100
Total for Group E	5	2	------	10	13	13	26	31	100

NUMBER OF PERSONS

Slight, present	1	------	------	1	1	1	------	------	4
Moderate, present	2	------	------	2	4	5	7	5	25
Severe, present, 1 month or less	------	1	------	2	------	------	4	2	9
Severe, present, more than 1 month	------	------	------	1	3	2	5	12	23
Total for Group E	3	1	------	6	8	8	16	19	61

TABLE 35.—*Stippling of red blood cells, by subgroups of Group B (users of automobiles with ethyl gasoline) divided according to estimated exposure*

	Stippled cells per 100,000 red cells								Total
	None	Very fine granules (questionable)		Definite stippling					
		1–3	Over 3	1–2	3–6	7–20	21–100	Over 100	
Subgroup 1	16	------	------	3	------	------	------	------	19
Subgroup 2	16	------	1	1	1	------	------	------	19
Subgroup 3	15	3	------	1	------	------	------	------	19
Subgroup 4	14	3	------	2	1	------	------	------	20
Total	61	6	1	7	2	------	------	------	77

TABLE 36.—*Stippling of red blood cells, by subgroups of Group D (garage workers and gasoline handlers exposed to ethyl gasoline) divided according to estimated exposure*

	Stippled cells per 100,000 red cells								Total
	None	Very fine granules (questionable)		Definite stippling					
		1–3	Over 3	1–2	3–6	7–20	21–100	Over 100	
Subgroup 1	6	1	------	4	1	2	------	------	14
Subgroup 2	8	1	------	4	1	1	------	------	15
Subgroup 3	8	------	------	3	2	1	------	------	14
Subgroup 4	7	------	------	5	1	1	------	------	14
Total	29	2	------	16	5	5	------	------	57

TABLE 37.—*Stippling of red blood cells in Group D (garage workers and gasoline handlers exposed to ethyl gasoline) in relation to acknowledged spillage of ethyl gasoline or of undiluted ethyl fluid on their persons*

	Stippled cells per 100,000 red cells								Total
	None	Very fine granules (questionable)		Definite stippling					
		1–3	Over 3	1–2	3–6	7–20	21–100	Over 100	
No acknowledged spillage of ethyl gasoline	7	1	------	3	1	1	------	------	13
Spillage of ethyl gasoline acknowledged [1]	21	1	------	10	3	4	------	------	39
Spillage of undiluted ethyl fluid (in most cases over one year ago) [1]	11	------	------	7	2	2	------	------	22

[1] Including 16 who spilled both ethyl gasoline and undiluted ethyl fluid.

TABLE 38.—*Analyses of 20 samples of feces from 10 presumably normal persons at Hygienic Laboratory, Washington, D. C.*

Sample from—	Ash	Total lead	Milligrams of lead per gram of ash	Sample from—	Ash	Total lead	Milligrams of lead per gram of ash
	Grams	*Milligram*			*Grams*	*Milligram*	
S	2.0	0.228	0.114	W	5.0	0.725	0.145
S	2.5	.181	.072	Ss	2.7	.501	.185
S	4.0	.411	.103	C	6.0	.46	.077
S	3.5	.66	.189	T	2.0	.19	.095
S	1.0	.22	.220	J	2.5	.41	.164
H	3.0	.173	.058	Sg	2.0	.58	.290
H	1.5	.138	.092	Blank	----	.00	----
H	4.7	.221	.047	Do	----	.00	----
H	3.0	.28	.093	Do	----	.00	----
H	5.5	.42	.076	Do	----	.00	----
R	2.5	.242	.097	Do	----	.00	----
R	5.6	.268	.048	Do	----	.00	----
Sn	1.4	.245	.174	H	1.5	.20	.133

TABLE 39.—*Lead in feces of persons grouped according to exposure: Milligrams of lead per gram of ash of feces*

PERCENTAGE

	0.030 and under	0.031–0.100	0.101–0.300	0.301–1.000	1.001–3.000	3.001 and over	Total
Group A	13	52	29	6			100
Group B	11	55	32	2			100
Subgroup 1	8	54	38				100
Subgroup 2	7	60	27	7			100
Subgroup 3	13	50	38				100
Subgroup 4	17	58	25				100
Group C	6	47	41	6			100
Group D	7	22	56	13	2		100
Subgroup 1	8	15	69	8			100
Subgroup 2	8	46	38	8			100
Subgroup 3	7	7	64	14	7		100
Subgroup 4	7	21	50	21			100
Group E	2		15	49	29	5	100
Subgroup M			75	25			100
Subgroup S1	5		10	71	14		100
Subgroup S					100		100
Subgroup S8			7	27	53	13	100
Total	8	34	35	16	7	1	100

NUMBER OF PERSONS

Group A	4	16	9	2			31
Group B	6	31	18	1			56
Subgroup 1	1	7	5				13
Subgroup 2	1	9	4	1			15
Subgroup 3	2	8	6				16
Subgroup 4	2	7	3				12
Group C	1	8	7	1			17
Group D	4	12	30	7	1		54
Subgroup 1	1	2	9	1			13
Subgroup 2	1	6	5	1			13
Subgroup 3	1	1	9	2	1		14
Subgroup 4	1	3	7	3			14
Group E	1		6	20	12	2	41
Subgroup M			3	1			4
Subgroup S1	1		2	15	3		21
Subgroup S					1		1
Subgroup S8			1	4	8	2	15
Total	16	67	70	31	13	2	199

TABLE 40.—*Lead in feces of persons grouped according to exposure: Total milligrams of lead in sample*

PERCENTAGE

	0.15 and under	0.16–0.50	0.51–1.50	1.51–5.0	5.01–15.00	Total
Group A	32	58	10			100
Group B	25	57	18			100
Subgroup 1	23	62	16			100
Subgroup 2	40	40	20			100
Subgroup 3	6	68	25			100
Subgroup 4	33	58	8			100
Group C	12	71	18			100
Group D	20	57	19	4		100
Subgroup 1	23	69	8			100
Subgroup 2	15	69	15			100
Subgroup 3	7	57	21	14		100
Subgroup 4	36	36	29			100
Group E	2	15	32	39	12	100
Subgroup M		75	25			100
Subgroup Sl	5	10	48	29	10	100
Subgroup S				100		100
Subgroup SS		7	13	60	20	100
Total	19	50	20	9	3	100

NUMBER OF CASES

Group A	10	18	3			31
Group B	14	32	10			56
Subgroup 1	3	8	2			13
Subgroup 2	6	6	3			15
Subgroup 3	1	11	4			16
Subgroup 4	4	7	1			12
Group C	2	12	3			17
Group D	11	31	10	2		54
Subgroup 1	3	9	1			13
Subgroup 2	2	9	2			13
Subgroup 3	1	8	3	2		14
Subgroup 4	5	5	4			14
Group E	1	6	13	16	5	41
Subgroup M		3	1			4
Subgroup Sl	1	2	10	6	2	21
Subgroup S				1		1
Subgroup SS		1	2	9	3	15
Total	38	99	39	18	5	199

TABLE 41.—*Lead in feces of persons grouped according to exposure: Milligrams of lead per gram of sample*

PERCENTAGE

	0.0030 and under	0.0031–0.0100	0.0101–0.0300	0.0301–0.1000	0.1001–0.3000	Total
Group A	58	38	4			100
Group B	49	47	2			100
Subgroup 1	45	55				100
Subgroup 2	47	47	7			100
Subgroup 3	47	53				100
Subgroup 4	60	40				100
Group C	53	47				100
Group D	46	48	4	2		100
Subgroup 1	46	46	8			100
Subgroup 2	62	38				100
Subgroup 3	29	57	7	7		100
Subgroup 4	50	50				100
Group E	5	27	34	32	2	100
Subgroup M		75	25			100
Subgroup Sl	5	27	43	24		100
Subgroup S				100		100
Subgroup SS	7	13	27	46	7	100
Total	40	42	10	7	1	100

NUMBER OF PERSONS

Group A	15	10	1			26
Group B	25	25	1			51
Subgroup 1	5	6				11
Subgroup 2	7	7	1			15
Subgroup 3	7	8				15
Subgroup 4	6	4				10
Group C	9	8				17
Group D	25	26	2	1		54
Subgroup 1	6	6	1			13
Subgroup 2	8	5				13
Subgroup 3	4	8	1	1		14
Subgroup 4	7	7				14
Group E	2	11	14	13	1	41
Subgroup M		3	1			4
Subgroup Sl	1	6	9	5		21
Subgroup S				1		1
Subgroup SS	1	2	4	7	1	15
Total	76	80	18	14	1	189

TABLE 42.—*Lead in feces of persons grouped according to exposure: Milligrams of lead per gram of ash of feces, after 0.05 is subtracted from total milligrams of lead found*

PERCENTAGE

	0.030 and under	0.031–0.100	0.101–0.300	0.301–1.000	1.001–3.000	Over 3.000	Total
Group A	29	48	16	6			100
Group B	20	54	25	2			100
Subgroup 1	23	54	23				100
Subgroup 2	13	60	26	7			100
Subgroup 3	13	56	31				100
Subgroup 4	33	42	25				100
Group C	6	59	29	6			100
Group D	13	39	39	7	2		100
Subgroup 1	15	31	46	8			100
Subgroup 2	15	69	15				100
Subgroup 3	7	29	50	7	7		100
Subgroup 4	14	29	43	14			100
Group E	2		20	46	27	5	100
Subgroup M			75	25			100
Subgroup Sl	5		14	71	10		100
Subgroup S					100		100
Subgroup SS			13	20	53	13	100
Total	15	38	27	14	6	1	100

NUMBER OF PERSONS

Group A	9	15	5	2			31
Group B	11	30	14	1			56
Subgroup 1	3	7	3				13
Subgroup 2	2	9	3	1			15
Subgroup 3	2	9	5				16
Subgroup 4	4	5	3				12
Group C	1	10	5	1			17
Group D	7	21	21	4	1		54
Subgroup 1	2	4	6	1			13
Subgroup 2	2	9	2				13
Subgroup 3	1	4	7	1	1		14
Subgroup 4	2	4	6	2			14
Group E	1		8	19	11	2	41
Subgroup M			3	1			4
Subgroup Sl	1		3	15	2		21
Subgroup S					1		1
Subgroup SS			2	3	8	2	15
Total	29	76	53	27	12	2	199

TABLE 43.—*Cars in Dayton municipal garage (a control garage)*

Make of cars	Number of cars	Number of cylinders
1½-ton Mack truck	6	4
Ford	21	4
3-ton Packard	1	4
Dodge	1	4
Chevrolet	2	4
Privately owned, stored during day by employees	12	4–6
Total	43	

TABLE 44.—*Carbon monoxide determinations at Dayton municipal garage (a control garage)*

Date	Time of sampling	Carbon monoxide in parts per 10,000	Remarks
Nov. 2, 1925	4 p. m	2	3 cars operating.
Do	4.10 p. m	3	Do.
Do	4.40 p. m	0	No cars operating.
Do	5.15 p. m	0	Do.
Nov. 3, 1925	6.40 a. m	2	2 cars operating.
Do	7 a. m	2	Do.
Do	11 a. m	0	1 car operating.
Do	11.30 a. m	2	2 cars operating.
Nov. 4, 1925	6.30 a. m	0	No cars operating.
Do	7 a. m	3	4 cars operating.
Do	7.15 a. m	2	2 cars operating.
Do	7.30 a. m	0	No cars operating.
Do	4 p. m	3	4 cars operating.
Do	4.30 p. m	2	2 cars operating.

TABLE 45.—*Cars in garage of public service corporation in Dayton (a test garage)*

Make of cars	Number of cars	Number of cylinders
Ford	31	4
Chevrolet	19	4
Dodge	8	4
Maxwell	2	4
Buick	5	6
Oldsmobile	3	4
Cadillac	1	8
White truck	5	4
G. M. C. truck	9	4
Service truck	3	4
Fordson tractor	1	4
Total	87	

TABLE 46.—*Carbon monoxide determinations made at garage of public service corporation in Dayton (a test garage)*

Date	Time of sampling	Carbon monoxide in parts per 10,000	Remarks
Oct. 29, 1925	1 p. m	0	No cars operating.
Do	1.06 p. m	2	2 cars operating.
Do	3.15 p. m	0	No cars operating.
Do	3.30 p. m	1	1 car operating.
Do	4 40 p. m	5	10 or more cars operating; peak period.
Do	5 p. m	7	Do.
Oct. 30, 1925	10 a. m	0	No cars operating.
Do	10.15 a. m	0	Do.
Do	4.15 p. m	0	Do.
Do	4.40 p. m	4	Peak period.
Oct. 31, 1925	6.30 p. m	1	Just at start of peak period.
Do	6.50 a. m	4	During peak period.
Do	10.10 a. m	0	No cars operating.
Do	10.15 a. m	0	Do.
Do	11.35 a. m	2	At start of peak period Saturday, closing at noon.
Do	11.50 a. m	4	At close of peak period.

TABLE 47.—*Carbon monoxide determinations at Cincinnati test garage*

Date	Time of sampling	Carbon monoxide in parts per 10,000	Remarks
Nov. 6, 1925	8 a. m	0	No cars being tested.
Do	8.30 a. m	0	Do.
Do	10 a. m	2	1 car tested for 2 minutes.
Do	10.12 a. m	2	Do.
Do	1 p. m	0	No cars being tested.
Do	1.19 p. m	9	Overhauled car tested for 20 minutes.

TABLE 48.—*Water analyses made at Hygienic Laboratory*

Sample No.	Residue on evaporation per liter	Lead found in 4 liters	Lead per liter	Calcium per liter	Magnesium per liter
Dayton:	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*
a	408.0	0.088	0.022	82.0	34.6
b	416.6	.104	.026	90.7	32.7
Cincinnati	223.3	.552	.138	36.5	6.6
Lead plant	145.1	.14	.035	33.2	7.5

TABLE 49.—*Routine analyses of tap water by Dayton city laboratory*

[Parts per million]

	Total solids	Alkalinity (HCO_3)	Temporary hardness	Permanent hardness	Total hardness	Total magnesia	Total calcium
1924							
January	460	330	271	78	349	35	82
February	382	330	271	86	357	31.46	91
March	380	321	263	89	352	33	86
April	390	326	268	85	353	32.7	87.6
May	420	335	275	97	372	34.94	91
June	440	333	273	96	369	32	91
July	440	340	279	93	372	34.8	91.68
August	440	353	290	83	373	32	97
September	415	353	290	86	376	33.6	95.5
October	490	341	280	80	360	32.7	90.5
November	473	339	278	88	366	38.4	84
December	428	325	267	92	359	33	89.75
1925							
January	430	353	290	70	360	40	79
February	470	339	278	82	360	32	91
March	400	323	265	84	349	32.7	86
April	470	335	275	87	362	34	88
May	471	308	253	88	341	33.2	82
June	480	335	275	85	360	32	91
July	408	335	275	73	348	31.5	88
August	501	400	335	35	370	37.8	86
September	416	390	320	92	412	39	101
October	410	341	280	88	368	33	93

TABLE 50.—*Routine analyses of tap water by Cincinnati waterworks laboratory*

[Expressed as ions, in parts per million]

	Ca	Mg	Fe	CO_3	SO_4	Cl
1923						
January	31.70	4.75	0.04	19.8	56.8	24
February	28.1	1.90	.03	18.0	51.3	16
March	29.2	1.67	.05	19.2	48.2	16
April	31.0	2.52	.10	21.6	45.6	15
May	31.8	5.18	.03	21.0	66.3	16
June	30.3	2.98	.06	24.6	50.3	14
July	37.8	2.28	.05	25.2	79.6	28
August	33.0	3.26	.05	24.6	57.5	23
September	39.6	5.54	.08	28.8	95.3	31
October	41.6	9.12	.05	33.0	74.1	32
November	50.1	6.91	.27	35.4	93.2	45
December	41.2	5.52	.20	24.6	79.2	31
Average, 1923	35.5	4.3	.08	24.6	66.4	24
1924						
January	28.10	4.49	.35	19.8	52.1	12.5
February	33.3	2.11	.30	21.6	61.2	19.0
March	31.1	2.95	.20	21.0	50.2	17.0
April	30.5	2.83	----------	15.8	53.6	15.0
May	28.5	3.53	.07	19.2	53.0	15.0
June	31.8	3.50	.07	26.4	54.4	15.0
July	35.2	4.37	.06	26.4	59.5	17.0
August	35.9	4.61	.15	28.2	64.9	19.0
September	40.1	5.71	.10	22.8	82.0	28.0
October	31.8	3.50	.10	22.2	54.6	20.0
November	34.7	6.10	.05	30.6	56.9	25.0
December	36.6	3.05	.10	24.0	59.1	29.0
Average, 1924	33.1	3.90	.14	23.4	58.8	19.5

TABLE 51.—*Dust and atmospheric findings in Dayton control garage*

	Calculated findings	Actual findings	Condition
Lead in dust sweepings	2.08 milligrams per gram.	15.36 milligrams total, 4.27 milligrams per gram ash.	From floor.
	1.65 milligrams per gram.	69.25 milligrams total, 2.31 milligrams per gram ash.	From floor and table.
	0 82 milligram per gram.	5.18 milligrams total, 1.30 milligrams per gram ash.	From floor and benches.
Lead in atmospheric dust by impinger.	0.38 milligram per 10 cubic meters.	0.16 milligram in 150 cubic feet.	Afternoon peak.
	0.16 milligram per 10 cubic meters.	0.14 milligram in 300 cubic feet.	4 peak periods
	0.07 milligram per 10 cubic meters.	0.05 milligram in 240 cubic feet.	Repair shop, middle of day.
	0.06 milligram per 10 cubic meters.	0.07 milligram in 420 cubic feet.	7 hours middle of day.
Lead in atmospheric particles by Drinker's precipitator.	0.7 milligram per 10 cubic meters.	0.01 milligram in 150 liters.	Morning peak.
	0.0 milligram per 10 cubic meters.	0.00 milligram in 150 liters.	Half hour in morning.
Lead in dust and vapor by charcoal method.	0.0 milligram per 10 cubic meters.	0.00 milligram in 900 liters.	Afternoon peak.
Carbon monoxide by pyrogallic tannic acid method.	0.03 per cent		4 cars operating.
	do		Do.
	do		3 cars operating.
	0.02 per cent		Do.
	do		2 cars operating.
	do		Do.
	do		Do.
	do		Do.
	do		Do.
	0.00 per cent		1 car operating.
	do		No cars operating.
	do		Do.
	do		Do.
	do		Do.

TABLE 52.—*Dust and atmospheric findings in Dayton test garage*

	Calculated findings	Actual findings	Condition
Lead in dust sweepings	22.31 milligrams per gram	72.50 milligrams total, 36.25 milligrams per gram ash.	From radiators, benches, and window sills.
	5.82 milligrams per gram.	24.16 milligrams total, 10.74 milligrams per gram ash.	From repair shop.
	4.54 milligrams per gram.	24.51 milligrams total, 6.29 milligrams per gram ash.	From garage floor.
	3.41 milligrams per gram.	131.18 milligrams total, 5.36 milligrams per gram ash.	From floor, table, and radiator tops in garage and repair shop.
Lead in atmospheric dust by impinger.	0.65 milligram per 10 cubic meters.	0.11 milligram in 60 cubic feet.	Afternoon peak.
	0.32 milligram per 10 cubic meters.	0.19 milligram in 210 cubic feet.	4 peak periods.
	0.18 milligram per 10 cubic meters.	0.47 milligram in 900 cubic feet.	2 night periods.
	do	0.26 milligram in 500 cubic feet.	8 hours in midday.
	0.14 milligram per 10 cubic meters.	0.12 milligram in 300 cubic feet.	Repair shop.
Lead in atmospheric dust by Drinker precipitator.	0.0 per 10 cubic meters	0.00 in 125 liters	Afternoon peak.
	do	0.00 in 150 liters	Do.
	do	do	Following morning peak.
Lead in dust and vapor by charcoal method.	0.0 per 10 cubic meters	0.00 in 1,800 liters	Night, during filling, spillage.
	do	do	Following morning peak, spillage.
	do	0.00 in 675 liters	Afternoon peak.
Carbon monoxide by pyrogallic tannic acid method.	0.07 per cent		Peak period.
	0.05 per cent		Do.
	0.04 per cent		Do.
	do		Do.
	0.03 per cent		Do.
	0.02 per cent		Beginning of peak period.
	do		2 cars operating.
	0.01 per cent		Beginning of peak period.
	do		1 car operating.
	0.00 per cent		No cars operating.
	do		Do.
	do		Do.
	do		Do.
	do		Do.
	do		Do.
	do		Do.

TABLE 53.—*Dust and atmospheric findings in Cincinnati control garage*

	Calculated findings	Actual findings	Condition
Lead in dust sweepings	6.19 milligrams per gram.	56.96 milligrams total, 10.55 milligrams per gram ash.	From under cars.
	2.40 milligrams per gram.	29.31 milligrams total, 3.51 milligrams per gram ash.	From benches and fixed tools.
Lead in atmospheric dust by impinger.	1.6 milligrams per 10 cubic meters.	0.09 milligram in 20 cubic feet.	6 men working.
Lead in atmospheric dust by Drinker precipitator.	0.0 milligram per 10 cubic meters.	0.00 milligram in 150 liters.	One-half hour in morning.
Lead in dust and vapor by charcoal method.	21.5 milligrams per 10 cubic meters.	1.94 milligrams in 900 liters.	Hour at noon.
Carbon monoxide by pyrogallic tannic acid method.	0.00 per cent		No cars operated in garage during entire period of tests.
	do		
	do		
	do		

TABLE 54.—*Dust and atmospheric findings in Cincinnati test garage*

	Calculated findings	Actual findings	Condition
Lead dust in sweepings	17.54 milligrams per gram.	160.50 milligrams total, 71.33 milligrams per gram ash.	From workbenches.
	5.18 milligrams per gram.	51.78 milligrams total, 6.47 milligrams per gram ash.	From floor.
Lead in cleansing kerosene.	0.14 milligram per cubic centimeter.	3.58 milligrams in 25 cubic centimeters.	Kerosene had been used as spray to clean carburetors.
		3.52 milligrams in 25 cubic centimeters.	
Lead in atmospheric dust by impinger method.	0.26 milligram per 10 cubic meters.	0.18 milligram in 240 cubic feet.	During testing of motor.
Lead in atmospheric dust by Drinker precipitator.	0.0 per 10 cubic meters	0.00 in 150 liters	Testing for 1 minute.
	do	do	Cars being tested.
Lead in dust and vapor by charcoal method.	do	0.00 in 1,800 liters	2 morning hours.
Carbon monoxide by pyrogallic tannic acid method.	0.09 per cent		Car tested for 20 minutes.
	0.02 per cent		Car tested for 2 minutes.
	do		Do.
	0.00 per cent		No cars running.
	do		Do.
	do		Do.

TABLE 55.—*Dust and atmospheric findings in a plant with definite lead hazard*

	Calculated findings	Actual findings	Condition
Lead in dust sweepings	Much over 300 milligrams per gram.	Very heavy precipitation.	Room B.
	Over 200 milligrams per gram.		Room F.
Lead in atmospheric dust by impinger method.	154 milligrams per 10 cubic meters.	26.23 milligrams in 60 cubic feet.	Room A
	51 milligrams per 10 cubic meters.	17.95 milligrams in 125 cubic feet.	Room B.
	24.4 milligrams per 10 cubic meters.	4.85 milligrams in 70 cubic feet.	Room C.
	14 milligrams per 10 cubic meters.	2.37 milligrams in 60 cubic feet.	Room D.
	7 milligrams per 10 cubic meters.	1.19 milligrams in 60 cubic feet.	Room E
	2.5 milligrams per 10 cubic meters.	0.43 milligram in 60 cubic feet.	Room F
	2.6 milligrams per 10 cubic meters.	0.45 milligram in 60 cubic feet.	Room G.
Carbon monoxide by pyrogallic tannic acid method.	0.00 per cent		Room A.
	do		Do.
	do		Room B.
	do		Do.
	do		Room C, 9.30 a. m.
	0.02 per cent		Room C, 10 a. m.
	do		Room C, 10.30 a. m.
	do		Room C, 10.40 a. m.
	0.00 per cent		Room D.
	do		Do.
	do		Room E.
	do		Do.
	do		Room F.
	do		Do.

TABLE 56.—*Controls on methods for estimating lead in air*

	Negative controls	Positive controls
Impinger method	Blank gave 0.02 milligram	20 cubic feet of fumes 19 hours after combustion of 470 cubic centimeters of 1 per cent tetraethyl lead in gasoline in 1,600 cubic feet chamber yielded 3.19 milligrams, or 56 milligrams per 10 cubic meters.
Drinker precipitator	Blank gave 0.00 milligram	25 liters of above fumes yielded 0.15 milligram, or 60 milligrams per 10 cubic meters.
Charcoal	Unexposed charcoal yielded 0.34 milligram in 400 cubic centimeters. This amount was subtracted in each case to give the amounts tabulated in Tables 51-55.	37.5 liters of air, which had evaporated 40 cubic centimeters out of 100 cubic centimeters 1 per cent tetraethyl lead in gasoline, saturated the charcoal with gasoline fumes and yielded 18.44 milligrams lead.

TABLE 57.—*Lead found in samples of gasoline*

	Source	Milligrams lead found	Milligrams lead per cubic centimeter	Calculated ratio, tetraethyl lead to gasoline, by volume	Percentage of maximum amount of lead (1:1260)
1925					
Oct. 13	Dayton control garage	0.00 in 50 cubic centimeters	0.00		
Nov. 2	do	0.00 in 25 cubic centimeters 0.00 in 25 cubic centimeters	.00		
Oct. 13	Dayton test garage	33.2 in 50 cubic centimeters 34.2 in 50 cubic centimeters	.67	1:1556	81
Oct. 29	do	16.70 in 25 cubic centimeters	.67	1:1556	81
Dec. 16	do	37.83 in 50 cubic centimeters 38.25 in 50 cubic centimeters 38.25 in 50 cubic centimeters	.76	1:1378	91
	Dayton test garage (special mixture).	36.73 in 50 cubic centimeters 37.00 in 50 cubic centimeters 36.80 in 50 cubic centimeters	.74	1:1410	89
	Dayton commercial ethyl gasoline:				
	Station 1	19.75 in 50 cubic centimeters 19.75 in 50 cubic centimeters 19.75 in 50 cubic centimeters	.40	1:2611	48
	Station 2	45.91 in 50 cubic centimeters 47.22 in 50 cubic centimeters 47.02 in 50 cubic centimeters	.93	1:1123	112
	Station 3	21.68 in 50 cubic centimeters 21.68 in 50 cubic centimeters 22.37 in 50 cubic centimeters	.44	1:2373	53
	Cincinnati control garage:				
Nov. 6	Ordinary gas	0.00 in 25 cubic centimeters 0.00 in 25 cubic centimeters	.00		
	Benzol gasoline	0.00 in 25 cubic centimeters 0.00 in 25 cubic centimeters	.00		
	Cincinnati commercial ethyl gasoline:				
Nov. 7	Station 1	8.01 in 25 cubic centimeters [1] 8.06 in 25 cubic centimeters [1] 7.99 in 25 cubic centimeters [2] 7.55 in 25 cubic centimeters [2]	.32 .31	1:3269 1:3373	39 37
Dec. 16	Station 1	23.0 in 50 cubic centimeters 22.8 in 50 cubic centimeters	.46	1:2266	56
	Station 2	17.8 in 50 cubic centimeters 17.5 in 50 cubic centimeters	.35	1:2987	42
	Station 3	12.04 in 50 cubic centimeters 11.73 in 50 cubic centimeters	.24	1:4355	29

[1] By first method. [2] By second method.

REPORT OF COMMITTEE OF SEVEN RECOGNIZED AUTHORITIES APPOINTED BY THE SURGEON GENERAL OF THE UNITED STATES PUBLIC HEALTH SERVICE TO PRESENT A STATEMENT AS TO THE HEALTH HAZARD INVOLVED IN THE RETAIL DISTRIBUTION AND GENERAL USE OF TETRAETHYL LEAD GASOLINE, MOTOR FUEL

By W. H. Howell, A. J. Chesley, David L. Edsall, Reid Hunt, W. S. Leathers, Julius Stieglitz, C.-E. A. Winslow

January 17, 1926.

Surg. Gen. H. S. Cumming,
United States Public Health Service,
Washington, D. C.

Dear Sir: The committee appointed by you at the request of the conference held in Washington May 20, 1925, was directed to present to you, "if possible by January 1 next, a statement as to the health hazards involved in the retail distribution and general use of tetraethyl lead gasoline motor fuel." As soon as practicable after its appointment the committee met in your office for organization and for discussion of the procedure to be followed in carrying out its instructions.

The members of the committee familiarized themselves, as far as possible, by conferences and by reading, with the existing data bearing upon the subject and upon lead poisoning in general. They had access to the stenographic report (see Public Health Bulletin No. 158) of the addresses and discussions which took place at the conference of May 20, and subsequently they made a personal examination of the plant at Deepwater, N. J., for the manufacture of tetraethyl lead, and of one of the stations at which the ethyl fluid is mixed with gasoline.

Ethyl gasoline was first placed on sale February 1, 1923, and its sale was voluntarily discontinued May 5, 1925, about 300,000,000 gallons of ethyl gasoline being distributed during this period. Serious cases of poisoning occurred among men handling lead tetraethyl and ethyl fluid in the States of New Jersey and Ohio. As far as the committee is aware these accidents had all occurred in connection with the manufacture and blending of concentrated tetraethyl lead, and threw no direct light upon the problem specifically laid before us—that of the

retail distribution and general use of ethyl gasoline. The valuable experiments reported by the United States Bureau of Mines and by investigators at Columbia University and others yielded important results, but we felt that the crucial test of the situation must be derived from actual experience in the use of ethyl gasoline under practical conditions of operation.

It was therefore decided that the committee should make a direct investigation of the question submitted to them, planning the work on as extensive a scale as was possible in the time allowed. Fortunately this mode of approach was made feasible by the fact that ethyl gasoline has been in constant use as a motor fuel in certain parts of Ohio for several years; and although the production and distribution of tetraethyl lead and ethyl fluid had been suspended by the voluntary action of the manufacturers, pending the present investigation, it was known that in the region indicated a supply of ethyl fluid was still in the hands of certain consumers and would be continued in use. We were thus presented with an opportunity of studying a fairly large group of individuals who had been using and handling ethyl gasoline and of comparing the findings upon them with the examination of a similar group employing gasoline free from lead.

In several conferences the committee, with the assistance of Surgeon General Cumming and Surg. L. R. Thompson, United States Public Health Service, in charge of the section of industrial hygiene and sanitation, formulated a general plan of investigation. The actual conduct of the work was intrusted to Dr. J. P. Leake, surgeon, United States Public Health Service, who at once organized a corps of workers and began observations upon certain groups of individuals in Dayton and Cincinnati. The committee desires to express its appreciation of the cordial cooperation extended to this group of observers by both the employers and workers in the garages selected for the investigations. After all the preliminary arrangements had been completed the work was pushed with great vigor during the autumn months, and on December 19 Doctor Leake presented to the committee a full report of the results of his study. The committee wishes to express its great satisfaction with the promptness, energy, and ability with which these investigations were carried out. The general character and scope of the work may be summarized briefly as follows:

Two hundred and fifty-two individuals were studied. They were all adult males and fall into five groups.

1. Group A, a control group, consisted of 36 men who were employees of the city of Dayton. Their duty was to drive cars during the working-day. In these cars the gasoline used contained no lead. The cars were housed in the municipal garage, which in the report is designated as the Dayton control garage.

2. Group B, a test group, consisted of 77 men who were employees of a public-service corporation in Dayton and whose duties were similar to those of Group A. The cars that they drove, however, used ethyl gasoline, and this fuel had been in constant use in this service since July, 1923. The garage in which these cars were housed is designated as the Dayton test garage.

3. Group C, a control group, consisted of 21 men. These were employed as garage workers in the Dayton control garage or in a similar control garage in Cincinnati, or as gasoline fillers at service stations or on trucks delivering gasoline in Dayton and the adjoining region. In none of these garages, service stations, or trucks was gasoline containing lead used or handled.

4. Group D, a test group, consisted of 57 men. These were employed as garage workers in the Dayton test garage or in a similar test garage in Cincinnati, or as gasoline fillers at service stations, wholesale gasoline plants, or on trucks delivering gasoline in Dayton, Cincinnati, and vicinity. The duties of these men were similar to those of Group C except that ethyl gasoline was handled in the garages, stations, and trucks.

5. Group E, a control group, consisted of 61 men employed in two industrial plants of entirely different character from the foregoing, in which there was known to be a serious exposure to lead dust. Numerous cases of lead poisoning had occurred in these plants. This group was selected to serve for what might be called a positive control or check in regard to the validity of the clinical and analytical methods used in the study of the individuals of Groups A, B, C, and D.

Methods used.—Each individual was subjected to a careful clinical examination, and in addition smears were made from his blood and a specimen of his feces was collected. The blood smears and the fecal specimens were sent to Washington to be examined by trained experts for stippling of the red cells and for content in lead. The examination of the feces for lead was made by chemists who had been especially trained in the technique of the method. The blood examinations were made by a group of skilled observers and were arranged so that the counts in each case were checked by several workers.

The clinical examination was conducted by four physicians. The first of these took a careful industrial history of each subject and assigned to him a certain number. These numbers were taken at random. Thereafter this individual was recorded by his number, and none of those making the subsequent examinations or the laboratory tests know whether or not the individual had been exposed to ethyl gasoline; nor, in fact, did any examiner, except the one who took the industrial history, know to which group the individual belonged.

After taking the industrial history other examiners made a thorough medical examination, including a medical history, hemoglobin estimation, red-cell count, blood-pressure records, visual acuity tests, urine examinations, etc., and finally a determination, by a special method devised for the occasion, of the muscular strength of the extensor and flexor muscles of the forearm.

While all of the examinations were made with as much care as possible, special attention was given to three methods which, it was hoped, would yield quantitative data of an objective character. These were, first, the determination of the amount of lead in the feces, as an index of lead ingestion or absorption; second, the estimation of the number of stippled red cells, which, in the absence of other causes, might also be considered as an index of lead absorption; third, measurements of the strength of the extensor muscles of the forearm, as an index of lead poisoning. The first two methods yielded results of positive value, but the last was practically negative so far as the present investigation is concerned.

When all the data had been collected, they were submitted to study and statistical analysis by Doctor Leake and his collaborators, and the results were presented to the committee in the form of a detailed report containing a description of the methods used, tabular summaries of results, and protocols of the findings for each individual studied. This report will be published in full by the Public Health Service.[1] So far as the clinical examinations are concerned, it may be said that they failed to give any decisive indication of lead posioning among the chauffeurs or workers in garages in which ethyl gasoline was used as a motor fuel. (Groups B and D.)[2]

The median time of potential exposure among these men approximated two years, and this negative result, therefore, holds good only for a period of this duration. It should be added that in Group E, comprising workers in industrial plants in which there was a known and serious exposure to lead dust, definite clinical symptoms of lead poisoning were revealed, although these workers had been exposed for shorter periods of time.

More significant results were obtained from the analysis of the feces and from the microscopic examination of the blood smears. These results are presented in condensed form in the accompanying graphs and tables. (Graphs 1 to 4 and Tables A, B, C, and D, pp. 112 to 115.)

Graph 1 and Table A represent the amount of lead found in the feces of the individuals of Groups A, B, C, D, and E. The figures along the abscissa of the graph give the amount of lead in milligrams

[1] Pp. 1–101 of this bulletin.

[2] The only injury observed was acute irritation of the eyes in a few cases, due to getting gasoline into the eyes. This occurred both with ordinary gasoline and with ethyl gasoline but was perhaps more severe in one case due to the latter. This case is mentioned specifically in the full report (pp. 15–16).

per gram of ash of the feces, from 0.1 milligram to 3 milligrams. The ordinates represent percentages of the workers in each group. It will be seen that in Groups A and B, representing drivers of cars, one using gasoline without lead and the other the ethyl gasoline, the amount of lead in the feces was practically identical. The exposure of these men was mainly to the exhaust gas from the motors, and it would appear that in Group B, using the ethyl gasoline, there was no positive indication of increased absorption of lead. The fact that in Group A some lead was also found in the feces shows that these men were exposed to lead from some other undetermined source. In this connection it is to be noted that 20 examinations were made in Washington by the same methods of the feces of 10 of the workers in the Hygienic Laboratory of the United States Public Health Service. These workers had had no known exposures to lead, but their feces showed at each examination small amounts of lead ranging from 0.047 to 0.290 milligram per gram of ash of the feces. In what might be called normal feces, therefore, lead may be present, from accidental exposures of one kind or another, in concentrations not differing materially from those found in Groups A and B.

In Group C, representing the garage workers and gasoline handlers not exposed to ethyl gasoline, there is an indication of a slightly greater excretion of lead. In the control garages and repair shops, as will be shown later, there was a perceptible amount of lead in the dust upon the floors and benches.

In Group D, representing the garage workers and gasoline handlers using ethyl gasoline, there is a still further increase in the amount of lead excreted, although the number who showed excretion of as much as 0.3 milligram per gram of ash is small (15 per cent). It seems probable that this increase was due to the use of ethyl gasoline, since subdivision of this group into two classes—those with a lesser exposure to ethyl gasoline as regards time and intensity, D1 and 2, and those with a greater exposure, D3 and 4—indicates that in the latter there was greater excretion, as is shown in Graph 2 and Table B.

In Group E, as would be expected, there is evidence of much greater ingestion or absorption. Over 80 per cent showed more than 0.3 milligram of lead for each gram of ash of the feces, and in some cases the lead was present in concentrations as great as 3 milligrams per gram of ash.

Graph 3 (see Table C) gives curves indicating the number of stippled cells found in the blood of the workers in Groups A, B, C, D, and E. The abscissa in this case represents the number of definitely stippled cells per 100,000; the curves are plotted for the values 1 to 2 per 100,000, 3 to 6, 7 to 20, 21 to 100.

Here again the results for Groups A and B are practically identical. In each group a small number, 12 per cent, showed definite stippling.

No examinations of persons who are neither drivers of cars nor garage workers are available, carried out by the same observers using the same method. It is not possible to say whether the slight degree of stippling observed with Groups A and B possesses any significance, but it seems to be clear that the members of Group B, exposed to the exhaust gases from engines using ethyl gasoline, showed no noticeable increase in stippling as compared with Group A.

In Group C there is a distinct increase in the percentage of workers showing stippling, and this increase is more marked in the workers of Group D. These results, therefore, corroborate the findings from the analysis of the feces in suggesting a beginning storage of lead in these two groups. That the greater indicated storage in Group D is connected with the use of ethyl gasoline seems to be borne out by the curves shown in Graph 4 (Table D), in which the curves are plotted for the two classes of D referred to above, the workers with the greater exposure showing a very slight increase in the percentage of those exhibiting definite stippling. The curve for the workers in Group E is of an entirely different character. Over 90 per cent showed distinct stippling, and in most of these cases the stippling was relatively very abundant.

Inquiry into reported cases of injury resulting from the use of ethyl gasoline.—So far as the committee could ascertain, all the reported cases of fatalities and serious injuries in connection with the use of tetraethyl lead have occurred either in the process of manufacture of this substance or in the procedures of blending and ethylizing. It seemed desirable to institute an inquiry in the region where this investigation was made, and where ethyl gasoline had been employed as a motor fuel for the longest time, as to possible cases of injury resulting from its use. All the workers examined were questioned, therefore, in regard to their knowledge of cases of possible injury, and inquiries were made in the Dayton and Cincinnati districts among local health officers, physicians, public-health workers, and labor leaders. The few clues obtained from this inquiry were investigated in detail, but the results were negative. No positive evidence could be obtained of harmful effects attributable to the use of ethyl gasoline.

Observations upon the lead in the dust and air of the garages investigated and upon the amount of carbon monoxide.—In addition to the examinations made upon the workers themselves, some data were collected in regard to the amount of lead in the air and dust of the garages and workrooms, and also in regard to the concentration of carbon monoxide. These observations were made during October, 1925, and owing to the unusually cool weather prevailing during that month, the doors and windows were closed during most of the day. The conditions regarding ventilation were those to be expected for

winter rather than summer weather. The several methods employed in this part of the investigation are given in detail in the full report.[3] The findings obtained are summarized in the accompanying tabular statements[4] for the several garages investigated as well as for an industrial plant in which there was a serious exposure to lead dusts. This part of the investigation was not so extensive as was desired, owing to the shortness of the time allowed, but it is evident from the results obtained that some lead was present in the air of the garages and workrooms whether the gasoline used contained lead or not; and in the sweepings of dust from the floors and benches there was a distinct amount of lead present, the figures running from 0.82 to 22.31 milligrams per gram of dust, according to the time and place of the gathering of the sample. It would seem probable, therefore, that in all garages in which automobiles are being handled and repaired the workers are constantly exposed to certain amounts of lead dust, and this fact would tend to emphasize the importance of providing such rooms with adequate ventilation and of keeping both the floors and the benches as free as possible from the accumulation of dust. Owing to the incompleteness of the data, it is not possible to say definitely whether the exposure to lead dust was greater in those garages in which ethyl gasoline was used. It is very desirable that these investigations should be continued.

On the basis of this investigation, the committee feels that the following general conclusions are justified:

1. Drivers of cars using ethyl gasoline as a fuel and in which the concentration of tetraethyl lead was not greater than 1 part to 1,300 parts by volume of gasoline showed no definite signs of lead absorption after exposures approximating two years.

2. Employees of garages engaged in the handling and repairing of automobiles and employees of automobile service stations may show evidence of lead absorption and storage, as indicated by the lead content of the feces and the appearance of stippled cells in the blood. In garages and stations in which ethyl gasoline was used the amount of apparent absorption and storage was somewhat increased, but the effect was slight in comparison with that shown by workers in other industries where there was a severe lead hazard (Group E) and for the periods of exposures studied was not sufficient to produce detectable symptoms of lead poisoning.

3. In the regions in which ethyl gasoline has been used to the greatest extent as a motor fuel for a period of between two and three years no definite cases have been discovered of recognizable lead poisoning or other disease resulting from the use of ethyl gasoline.

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[3] Pp. 31-38. [4] Tables 51-55, pp. 97-100.

In view of these conclusions your committee begs to report that in their opinion there are at present no good grounds for prohibiting the use of ethyl gasoline of the composition specified as a motor fuel, provided that its distribution and use are controlled by proper regulations. The committee feels that the formulation of specific regulations in regard to the manufacture, distribution, and use of tetraethyl lead, ethyl fluid, and ethyl gasoline for adoption and enforcement by the several States belongs properly to the office of the Surgeon General of the Public Health Service. In an appendix to this report attention is called to certain suggestions which have been made in the course of the discussions of this committee and which it is believed should be taken into consideration in making such regulations.

In conclusion we beg to say that we are conscious of the fact that the conclusions to which we have come in this report, although based upon most careful and conscientious investigations, are subject to the criticism that they have been derived from the study of a relatively small number of individuals who were exposed to the effects of ethyl gasoline for a period of time comparatively brief when we consider the possibilities in connection with lead poisoning. A more extensive study was not possible on account of the limited time. It remains possible that, if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would appear to be the case from this investigation. Longer experience may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognizable lead poisoning or to chronic degenerative diseases of a less obvious character. In view of such possibilities the committee feels that the investigation begun under their direction must not be allowed to lapse. The respective States would be dependent upon the findings of such investigations for changes in their regulations. With the experience obtained and the exact methods now available, it should be possible to follow closely the outcome of a more extended use of this fuel and to determine whether or not it may constitute a menace to the health of the general public after prolonged use or under conditions not now foreseen.

Outside the question of ethyl gasoline it would seem from this investigation that wherever automobiles are housed together there is an accumulation of lead dust which may prove to be a source of danger to the workers involved, in addition to the hazards arising from the production of carbon monoxide gas. The vast increase in the number of automobiles throughout the country makes the study of all such questions a matter of real importance from the stand-

point of public health, and the committee urges strongly that a suitable appropriation be requested from Congress for the continuance of these investigations under the supervision of the Surgeon General of the Public Health Service, and for a study of related problems connected with the use of motor fuels.

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TABLE A.—*Percentage of persons with more than one-tenth milligram of lead per gram of ash in feces in the exposure groups A, B, C, D, and E*

[Milligrams of lead per gram of ash]

	0.101–0.300	0.301–1.000	1.001–3.000	3.001 and over
A	29	6	.....	.....
B	32	2	.....	.....
C	41	6	.....	.....
D	56	13	2	.....
E	15	49	29	5

TABLE B.—*Percentage of persons with more than one-tenth milligram of lead per gram of ash in feces in Group C and half Groups D1–D2 and D3–D4*

[Milligrams of lead per gram of ash]

	0.101–0.300	0.301–1.000	1.001–3.000	3.001 and over
C	41	6	.....	.....
D1 and D2 [1]	54	8	.....	.....
D3 and D4	57	18	4	.....

[1] D1 and D2 are the two quarters of exposure Group D which had less exposure to ethyl gasoline and ethyl fluid and D3 and D4 are the two quarters which had the greater exposure.

TABLE C.—*Percentage of persons showing definite stippling of different degrees in exposure groups A, B, C, D, and E*

[Stippled cells per 100,000 red cells]

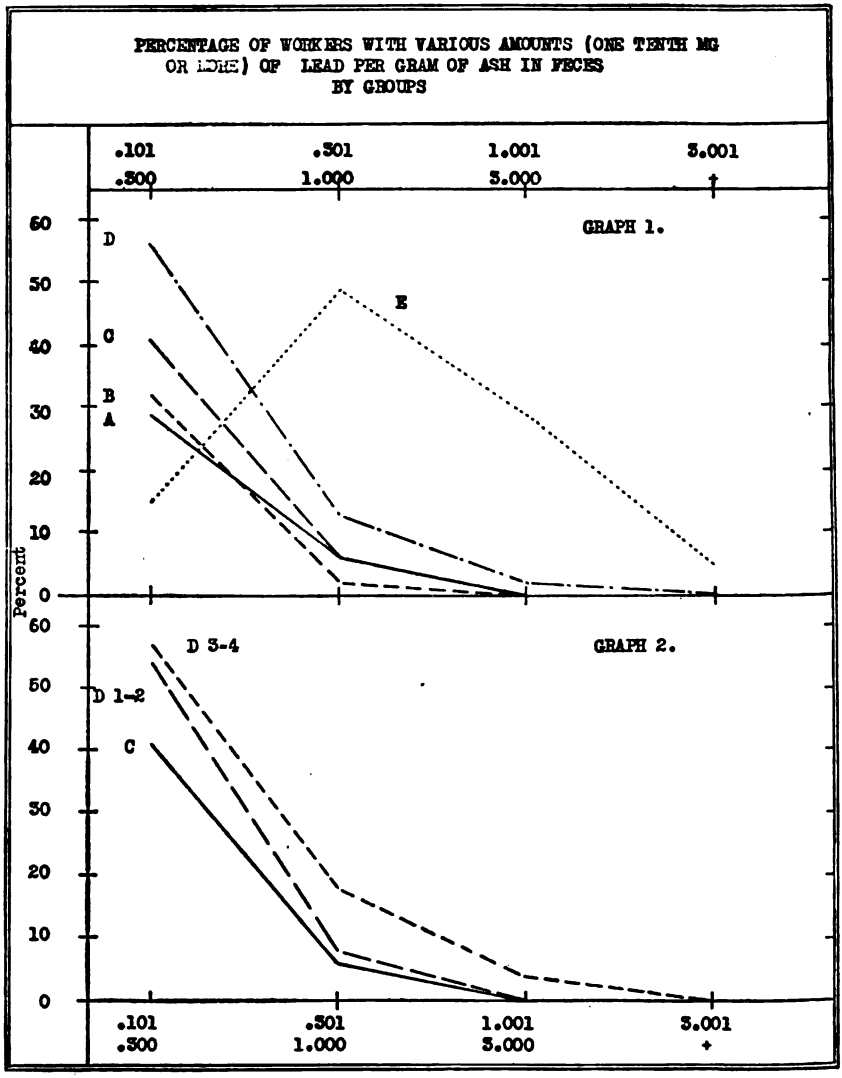
	1–2	3–6	7–20	21–100	Over 100
A	6		3	3	
B	9	3			
C	19	5			
D	28	9	9		
E	10	13	13	26	31

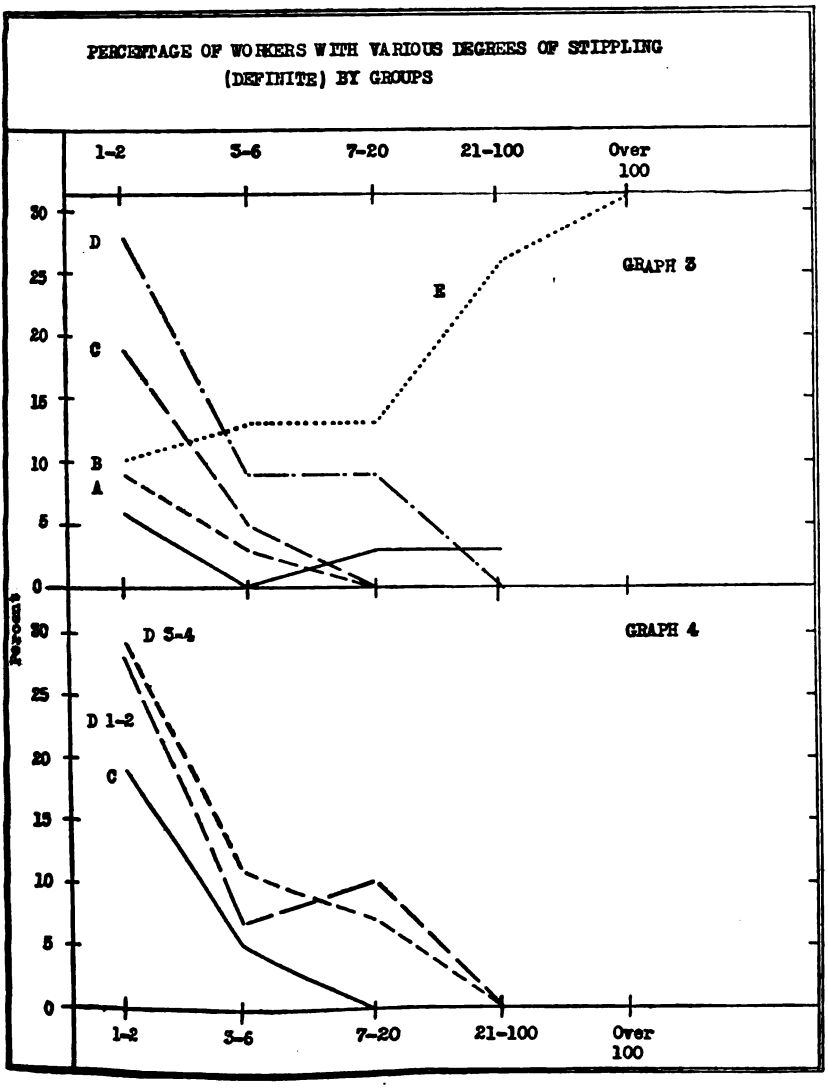
TABLE D.—*Percentage of persons showing definite stippling of different degrees in group C and half groups D1–D2 and D3–D4*

[Stippled cells per 100,000 red cells]

	1–2	3–6	7–20	21–100	Over 100
C	19	5			
D1 and D2 [1]	28	8	10		
D3 and D4	29	11	8		

[1] D1 and D2 are the two quarters of exposure Group D which had less exposure to ethyl gasoline and ethyl fluid and D3 and D4 are the two quarters which had the greater exposure.





REGULATIONS PROPOSED FOLLOWING THE TETRAETHYL LEAD INVESTIGATION

These regulations have been formulated in accordance with the recommendations of the Surgeon General's committee, under whose direction the investigation into the hazards from tetraethyl lead gasoline was conducted. They are proposed for adoption by the several States in order to secure uniformity of control and were the subject of consideration at the meeting of the State and Territorial health authorities with the Surgeon General on May 25, 1926. These regulations are based upon present conditions and knowledge and it is appreciated that changes may be advisable from time to time.

By the term "tetraethyl lead" is meant the chemical substance $Pb(C_2H_5)_4$ of a commercial grade of purity or higher. Ethyl fluid is the concentrated commercial fluid containing tetraethyl lead and other ingredients, which is to be mixed with gasoline to make ethyl gasoline. The manufacture of ethyl fluid consists in adding these other ingredients to tetraethyl lead and is called "blending." The process of adding the ethyl fluid to gasoline to form ethyl gasoline is called "mixing." In the term "ethyl gasoline" as herein used are included all other motor fluids containing tetraethyl lead.

I. Proposed regulations for the manufacture of tetraethyl lead and the blending of the latter to make ethyl fluid.

II. Proposed regulations for mixing.

III. Proposed regulations for distribution of ethyl gasoline.

IV. Proposed regulations for automobile garages, repair shops, service stations, and filling stations.

Proposed Regulations for the Manufacture of Tetraethyl Lead and the Blending of the Latter to Make Ethyl Fluid

1. No person shall be employed without adequate instructions as to the nature of the hazard and the precautions to be taken.

2. Each worker shall have a periodical physical examination, which shall consist of such physical and other tests as are indicative of the absorption of tetraethyl lead and shall include, as a minimum, the following items:

(*a*) Examination of blood for stippling by carefully trained workers, using positive and negative controls, without knowledge of the source of the slides; this examination shall be once a week for the first three weeks and bimonthly thereafter.

(*b*) Semimonthly contact with plant physician for informal statement as to general health.

(*c*) Bimonthly weight, stripped.

(*d*) Bimonthly systolic and diastolic blood pressure estimation while sitting.

(*e*) Bimonthly hemoglobin estimation by Dare's hemoglobinometer.

Exact records of these examinations shall be kept, and persons showing gradually increasing amounts of stippling, sudden development of stippling, or other marked deviation from normal shall be promptly excluded from tetraethyl lead work, irrespective of whether or not such finding may be indicative of lead poisoning. All parts of the plants where lead in any form is used shall be subject to sanitary measures to prevent collection and dissemination of lead dust.

4. Separate ventilation systems shall be provided for the manufacturing apparatus and for the air of the rooms, the outlets of the latter being located near the floor of each room and all external inlets and outlets being so situated as to avoid dustiness and appreciable contamination of the air around the plant.

5. Daily inspection shall cover efficiency of ventilating systems, all joints, valves, and gaskets of manufacturing apparatus, and adequacy of pressure-hose respirators.

6. All containers of ethyl fluid or tetraethyl lead shall be labeled as to exact content and danger and shall conform to the regulations of the Interstate Commerce Commission. These containers shall be carefully tested for leaks and shall bear a plainly legible label stating that they are to be closed tight immediately when emptied, without cleansing, and sent back to the plant.

7. Kerosene or other material used for cleansing the used containers of ethyl fluid or tetraethyl lead shall be placed in the containers

by means of a closed system with air vents to outside air and with adequate ventilation.

8. The filling shall be performed by means of a closed system with air vent from the container to the outside air, and with adequate ventilation.

9. A dye shall be added to ethyl fluid in sufficient amount to give staining qualities to the ethyl gasoline to deter individuals from using it for cleansing or other similar purposes.

10. Reports shall be made monthly to the appropriate officer of the State concerned covering the following points:

Number of workers employed at beginning of month.
Number of workers employed at close of month.
Number of new workers.
Number of workers separated from tetraethyl lead work on account of results of examinations.
Number of definite cases of poisoning.
Condition of cases of poisoning previously reported so far as known.

Proposed Regulations for Mixing

1. The maximum content of tetraethyl lead in commercial ethyl gasoline shall be in the proportion of 1:1,260 by volume for commercial tetraethyl lead, or 1:1,300 for Pb $(C_2H_5)_4$ C. P.

2. Mixing ethyl fluid with gasoline except for certain specific requirements such as research, military and naval use, and air-mail service shall be done only at the main distribution centers and in not less than tank-car lots. Adequate provision shall be made at each such center for thorough mechanical distribution of the ethyl fluid throughout the gasoline, and the efficiency of such distribution shall be controlled by the analysis of samples.

3. The locations of these centers and the names of persons engaged in mixing shall be reported to the State department of health of the State of employment.

4. As few persons at each center as practicable shall be employed for this work.

5. No person shall be engaged for mixing until adequately instructed as to the mechanics of mixing, the dangers, and the precautions to be taken.

6. The distributor of ethyl fluid shall provide a special corps of adequately trained instructors and service men.

7. All mixing shall be done with the maximum ventilation practicable under weather conditions existing at the time.

8. Operation of the pumps shall be instantly stopped at the appearance of a leak or other defect, and no attempt shall be made to repair or disconnect the system until a qualified man takes personal charge of it.

9. Floors of all places where any possibility of spilling is present are to be provided with drains and proper facilities for making possible a complete flushing out of all spilled fluid, or in their absence provision shall be made for chemically neutralizing any spillage as it occurs.

10. No bulk mixing station shall be dismantled or disconnected for repairs except by a qualified man.

11. Kerosene or other efficient means of preventing skin absorption of tetraethyl lead and washing facilities shall always be conveniently available.

12. The rules and instructions affecting the employees shall be posted in a conspicuous place where the ethyl fluid is being handled.

13. The distributor of ethyl fluid shall, with the advice of the United States Public Health Service, select a representative group of at least 40 men exposed to the hazard of mixing, representing the entire area of distribution. This group shall serve as an index of the hazard of mixing. Monthly for the first three months and every

four months thereafter this group of employees shall have an examination, which shall consist of:

(*a*) Examination of blood for stippling, by carefully trained workers, using positive and negative controls, without knowledge of the source of the slides.

(*b*) Examination of fecal samples of lead.

(*c*) Report as to general state of health.

(*d*) Weight, stripped.

(*e*) Blood-pressure estimation, diastolic and systolic, when sitting.

(*f*) Hemoglobin estimation by Dare instrument.

Exact records of these examinations shall be kept.

14. The results of the examinations shall be reported promptly to the Surgeon General of the Public Health Service.

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