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HEARINGS
Before The
SUBCOMMITTEE ON AIR AND WATER POLLUTION
COMMITTEE ON PUBLIC WORKS
UNITED STATES SENATE

S. 3112, S. 3400 AND RELATED BILLS
AIR POLLUTION ABATEMENT

Washington, D. C.

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U. S. Senate,

Washington, D.

Subcommittee on Air and Water
Pollution of the Committee on
Public Works.

June 9, 1966

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1 Senator Muskie. Our next witness will be Dr. Robert A.
2 Kehoe, of the University of Cincinnati College of Medicine,
3 Cincinnati, Ohio.

4 Dr. Kehoe, we appreciate your coming here this morning
5 and further enlightening the committee.

6 Dr. Kehoe. Thank you.

7 Senator Muskie. You may proceed.

8 May I say for the benefit of all of us that you may
9 cover as much of your prepared testimony as you want
10 orally but we will include it all in the record. We don't
11 object to listening to it if you wish to read it all.

12 STATEMENT OF DR. ROBERT A. KEHOE, UNIVERSITY OF
13 CINCINNATI COLLEGE OF MEDICINE, CINCINNATI, OHIO

14 Dr. Kehoe. First of all I would like to say I appreciate
15 the opportunity of being here. I have no hope whatever of
16 being able to present to your committee other than in terms
17 of documents, published materials, the information that is
18 available then on this subject.

19 I am afraid we would be here the rest of the week if
20 I were to undertake to do this. So that what I shall do
21 is briefly to outline where it appears to me that we stand
22 in this situation at the present time, to briefly refer
23 to the evidence that puts us in my opinion in that position
24 and to refer to you and your committee and its staff the
25 published material on this subject which is here.

1 There is a much longer memorandum that I should not
2 dare to undertake to present here this morning, with reference
3 material and a series of reproductions of the material that
4 is in various reports, in literature, in this country and
5 abroad which we have put together in this fashion, primarily
6 because of this -- much of this is very difficult to obtain.

7 It goes clear back to 1923 and 1924 and is not readily
8 available in the journals that exist at the present time.
9 Some of this has actually been lost.

10 Senator Muskie. Is it your intent to make this available
11 for the files of the committee?

12 Dr. Kahoe. That is right. This is for the purpose
13 of making this available. Another copy of this is available
14 if it would be of any interest.

15 Senator Muskie. Would it make interesting
16 night reading?

17 Dr. Kahoe. Several nights. It would not be a thousand
18 and one but it would be several.

19 I would like to briefly state my own position at the
20 present time if I may.

21 It is the purpose of this statement to present briefly
22 the salient facts concerning the hygienic aspects of the
23 occurrence and distribution of lead in the environment of
24 citizens of the United States of America, with particular
25 reference to the contribution made by the use of leaded

1 gasoline.

2 I am a physician, at present too the one Professor
3 Emeritus of Occupational Medicine in the Department of
4 Environmental Health in the College of Medicine, University
5 of Cincinnati. I have been a teacher and professor on the
6 faculty of the college of Medicine in the Department of
7 Pathology, first, in Physiology and later and longer Director
8 of Cattering Laboratory which has been concerned with industrial
9 medicine and industrial hygiene from its founding in 1930
10 until my retirement in 1965.

11 Incidentally it still continues. From 1948 until 1965
12 I was the Director of the Department of Preventive Medicine
13 and Occupational Health in the area the laboratory is
14 situated. I was also the Chief Medical Consultant with
15 the title and corporate responsibilities of Medical Director
16 of Ethyl Corporation from 1925 until I retired at the
17 end of 1958.

18 This having been imperative in the early stages because
19 I was the only person who was involved with the early
20 study of tetraethyl lead.

21 The impression has existed in certain circles that
22 little information is available on this subject, especially
23 as to matters that relate to the safety of the public.

24 The fact is, however, that no other hygienic problem
25 in the field of air pollution has been investigated so

1 intensively, over such a prolonged period of time, and with
2 such definitive results. This is not to claim that there
3 are no significant voids in the available information, nor
4 that all of the ultimate answers are at hand.

5 Nevertheless, it is clear that this specific set of
6 problems has been brought to such a point of understanding,
7 in relation to the public health, as to remove it from the
8 realm of urgency and to consign it into that group of hygiene
9 problems on which a watchful and effective surveillance should
10 be kept. A considerable measure of assurance for the
11 future may also be derived from the fact that methods of
12 surveillance have been developed, over the years of
13 investigation, which are characterized by a high degree of
14 technical precision and physiological relevance.

15 Senator Muskie. Is it fair to say, Dr. Kehoe, that what
16 you have just said is at variance with the position taken
17 by the Public Health Service and the position taken by Dr.
18 Hardy this morning as to the state of knowledge that we ought
19 to have before reaching final conclusions?

20 Dr. Kehoe. Not precisely, no, sir. I would simply
21 say that in developing the information along this line for
22 which I have had a greater responsibility than any other
23 person in this country, that we have undertaken to answer
24 the question that relates specifically to the public health.

25 Our interest has been broader, I may say, more extensive,

1 in the field of industrial health in which the problem is most
2 serious and it is most serious. But that with respect to the
3 findings here I would say at this point that we are in the
4 best position that we have been at any time in the 35 year
5 period since lead and gasoline was introduced on the American
6 market.

7 With respect to the information that is necessary to
8 answer the questions that are available, they are not all
9 answered and there are still investigations to do. But I
10 repeat that the situation is in no sense urgent.

11 Senator Muskie. With respect to this sentence in your
12 testimony " No other hygienic problem in the field of air
13 pollution has been investigated so intensively over such a
14 long period of time and with such definitive results,"-- is
15 it your intention that that statement apply not only as to
16 industrial exposure to the problem but also to the
17 exposure of the general public to leads in the atmosphere?

18 Dr. Kehoe. Not at all, sir.

19 The industrial exposure is with us, it is a hazard.
20 Lead poisoning in industry is still one of the most frequent
21 occupational diseases with which we are presented in this
22 country despite the fact that we know how to prevent it.

23 The question with respect to the public has been
24 from the very start, 1923 on, hypothetical, a potential
25 risk which we have been undertaking to measure by every means

1 which we can get at and the evidence at the present time is
2 better than it has been at any time that this is not a present
3 hazard.

4 Senator Muskie. May I ask a further question on this?
5 The Bureau of Mines and the American Petroleum Institute
6 have just entered into a contract involving \$480,000 of
7 American Petroleum Institute money to conduct research
8 in this field. Is that in your judgment a reflection of
9 concern or simply routine?

10 Dr. Kehoe. Not with respect to lead. The concern here
11 is with other aspects of the use of petroleum hydrocarbon
12 fuels which do present us with a series of problems some of
13 which are unsolved.

14 Senator Muskie. I understood the contract does relate
15 to lead.

16 Dr. Kehoe. It relates to both, lead and unleaded
17 gasoline, with the idea of establishing whether the lead
18 introduces an additional factor. There is no question however
19 about the factor of risk of a sort from the petroleum
20 hydrocarbons. The question at issue here which is being
21 carried out along with the general investigation is whether
22 lead enters into this problem and in any way affects the
23 matter disadvantageously.

24 Senator Muskie. Would you say that from the point of
25 view of health it would be desirable, if not urgent --
you have indicated it is not urgent -- but from the point

1 of view of health would it be desirable if a substitute
2 for lead could be found for gasolines?

3 Dr. Kehoe. If by this means one could accomplish the
4 same purpose, and mind you I am not interested in the
5 economics of the things other than the avoidance of upsetting
6 the whole community, this is not my concern -- there is nothing
7 at the present time that would say to you or to me that
8 we should hurry to eliminate lead from the gasoline in the
9 country.

10 There is no evidence that this has introduced a danger
11 in the field of public health. There is still the hypothetical
12 question, and this is largely because we have long known
13 that lead has the potentiality of grave danger, that it
14 produces illness, that it still produces illness.

15 We have known only for a relatively short time, since
16 I may say the work of the Kettering Laboratory in this field,
17 that lead is an inevitable element in the surface of the
18 earth, in its vegetation, in its animal life, and that there
19 is no way in which man has ever been able to escape the
20 absorption of lead if he lived on this planet.

21 If there is any other planet this is another matter.
22 This has always been the case and it will continue to be
23 despite our efforts. The question therefore is how much
24 danger is there, how much does it take to create danger and
25 what is the margin of safety that exists at the present time

1 between that is what would be dangerous and what is certainly
2 not dangerous.

3 Senator Muskie. I am not certain you have answered
4 my question so I would like to ask it again.

5 Dr. Kehoe. I am not avoiding it. I am just trying
6 to give you a full answer, sir.

7 Senator Muskie. I understand. Putting aside the
8 question of economics, which we both agree should be
9 put aside, if you have a substitute for lead, a clearly non
10 toxic substitute for lead that would do the same job that
11 lead does would you think it desirable from the point
12 of view of health to make the substitution.

13 Dr. Kehoe. I should be indeed in this very cautious
14 in arriving at any such conclusion. I would not be unable
15 to arrive at it without investigation in advance of the
16 fact. If investigation demonstrated the truth of what you have
17 just said --

18 Senator Muskie. I have asked you to assume the truth
19 of what I have said. Obviously it is hypothetical and the record
20 will be clear on that point.

21 Assuming the truth of what I have said, assuming in
22 fact you had such a substitute, would you say from the point
23 of view of health that the substitute ought or ought not
24 to be accepted? Because then the only question involved
25 would be economics.

1 Dr. Kehoe. Yes. I am only saying I cannot make such
2 an assumption because there would have to be information of
3 the various materials that have been recommended, that have
4 been thought of in this connection as substitutes for
5 tetra lead. None at the present time has turned out to be
6 satisfactory and none has been devoid of certain considerations
7 in the field of public health which would have to be answered.

8 Now I would only take this position. We have have
9 experienced with tetraethyl lead since 1923 which clearly
10 indicates, to me, that this is not a present hazard. We would
11 not have that kind of information in relation to any other
12 material that I can conceive of as being put in this
13 capacity, and therefore, I am careful about the answer to
14 your question.

15 If I could assume that everything is perfect about it,
16 which I cannot do, then I would agree with you.

17 Senator Muskie. I think that is a hypothetical question
18 you can make that assumption. Frankly I am disturbed that you
19 are not sure enough about the body of knowledge upon which
20 you are relying to answer such a hypothetical question,
21 and I said assuming, clearly assuming as a fact, recognizing
22 it has yet to be established as a fact, assuming as fact
23 there is a substitute.

24 Or there could be developed a substitute for lead
25 that would do the same thing for gasoline that lead does,

1 but without any toxicity, any toxic effects, would you say
2 from the point of view of health that it would be desirable
3 or not desirable to make the substitution?

4 I think that is a question that a man with your background
5 like this ought to be able to answer.

6 Dr. Kehoe. I could answer it except that I take the
7 point of view as a matter of principle that we must
8 investigate every material that we introduce into our
9 environment --

10 Senator Muskie. I do quarrel with that.

11 Dr. Kehoe. -- because there are unknown effects.

12 Now to answer your question, if I could be quite sure
13 that this was the case I would be glad to dispense with
14 a risk, the question of risk, not the question of hazard
15 because I think it does not exist, but the question of
16 potential hazard which is risk.

17 I would be glad to trade any risk for the
18 certainty of safety.

19 Senator Muskie. All right. I guess that is as close
20 as we can come together.

21 Dr. Kehoe. The bulk of the investigative work which
22 bears on lead in the general environment of man has been
23 carried out, under the financial sponsorship of the
24 manufacturers and distributors of lead containing anti knock
25 compounds in the United States, in the Kettering Laboratory,

1 in the Department of Preventive Medicine and Industrial
2 Health of the College of Medicine of the University of
3 Cincinnati, and under the terms of agreements between the
4 executives of the industries concerned and the Board of
5 Directors of the University, whereby the public responsibilities
6 of the University have been preserved intact. This Department
7 has been renamed, recently, the Department of Environmental
8 Health.

9 Facts brought to light by these investigations have
10 been confirmed by evidence derived from the examination of
11 similar situations by official investigators in other
12 countries, and from extensive tangential applications of the
13 methods of other countries, and from extensive tangential
14 applications of the methods of our investigations. Principally
15 to the industrial scene.

16 When an investigation, undertaken jointly by the United
17 States Public Health Service, and the Health Departments
18 of the City of Philadelphia and the State of California
19 and the Kettering Laboratory, was completed, and the
20 results were published, in 1965, under the title of a "Survey
21 of Lead in the Atmosphere of Three Urban Communities,"
22 these being Philadelphia, Los Angeles, and Cincinnati,
23 the reliability of the past info and the current information,
24 as well on the lead content of the atmosphere of cities was
25 established beyond further question. It is now possible

1 to consider any future potential threat to the public health
2 in this matter on the background of a body of data which will
3 serve as a baseline for comparison.

4 Incidentally, there has been reference, this is off
5 the record here, this is oral -- there has been reference
6 to 11 high values found in that survey. I should like to
7 report to you that those values were considered to be pure
8 chance phenomenon that in a statistical distribution of
9 values which begin on the low side and which taper out
10 into the high side. The results of those men who are
11 available at the present time, which consist of four
12 people in Cincinnati, three people in California, have been
13 rechecked and the results in this instance, as could more
14 or less be predicted, come right back then into the main
15 body of the data.

16 All of the results fortuitously turned out to be quite
17 on the low side of the mean value rather than high.

18 Senator Muskie. Let me ask you this. In the statement,
19 simply to give you the opportunity to emphasize what you have
20 said, you say that on the basis of the study in Philadelphia,
21 Los Angeles, and Cincinnati, the reliability of the current
22 information on the lead content of the atmosphere of cities
23 was established beyond further question.

24 That is a pretty strong statement for a scientific
25 man to make unless he means it.

1 Dr. Kehoe. I mean it very definitely, sir.

2 Senator Muskie. You can anticipate no variations from
3 the findings in these three cities and any other place in
4 the U. S. any time in the future that would raise a real
5 question?

6 Dr. Kehoe. Not the latter, not in the future.

7 Senator Muskie. You say beyond future question.

8 Any question that would be raised would have to be
9 in the future with reference to the point in time that that
10 study is made.

11 Dr. Kehoe. I spoke specifically of current information.
12 I shall speak of the future a little later.

13 Senator Muskie. So that there is further question if
14 you think in terms of further as referring to the future.

15 Dr. Kehoe. There is this question, yes, to which
16 there is some degree of answer. But the question at this
17 point in our discussion is completely open. I am not
18 anticipating the future at this point.

19 Senator Muskie. Still, Doctor, let me clarify this
20 further. Your next sentence says it is now possible to
21 consider any future potential threat to the public health
22 in this matter on the background of a body of data which
23 will serve as a baseline for comparison.

24 That would seem to suggest that your baseline even
25 as to the future is not going to move.

1 Dr. Kehoe. That was not the intention. That there is
2 a baseline with which you can compare future observations.
3 One of the primary purposes of this investigation which
4 was emphasized by the Surgeon General and the Committee was
5 that there was not enough data distributed over a wide enough
6 number of American cities so that we had a baseline to say,
7 if today is all right, does tomorrow vary from this and
8 particularly does it vary upward?

9 Is there in other words a future danger in the ever
10 increasing automobiles, in the increased use of lead in gasoline
11 in the increased distribution of lead in the atmosphere
12 from any and all sources?

13 The hygienic issue, at this time, relates to the total
14 pattern of the concentration of lead, from all sources, in
15 the respired air of persons in the general population, in
16 conjunction with the quantities ingested with their food
17 and beverages and any other material that is swallowed. The
18 mere abundance of lead in the human environment is not of
19 itself a threat to mankind, nor in the final analysis is the
20 mere presence of lead within the anatomical structure of
21 man.

22 Abundance is a non-quantitative term, and the outcome
23 of the absorption of lead into the human tissues -- the
24 internal media of the body, depends upon its rate and
25 extent, and upon the physiological mechanisms which are

1 involved in its entrance and exit, its systemic and
2 cellular distribution, and in the metabolic processes in the
3 tissues, including also, the elimination of absorbed lead from
4 the body, and the extent of the accumulation, if any, in the
5 body with time.

6 The natural environment of mankind is such that lead
7 is taken into the human body in virtually all food and
8 beverages and in the respired air. The many usages to which
9 lead is put in modern industrial society, one of which
10 is involved in the present discussion, have increased the
11 amounts which the average man ingests and inhales, with the
12 result that somewhat more than natural quantities of lead
13 enter into the metabolic processes of his body.

14 The quantities are small but not insignificant. The food
15 consumed by an adult in the United States contains lead in
16 amounts which range from less than .1 mg. to 4.0 mg.
17 Occasionally more per day. The higher and lower values
18 mentioned occur infrequently, the larger proportion of the
19 daily quantities grouping themselves regularly and closely
20 around the mean value which is somewhat less than 0.3 mg.
21 per day.

22 The quantities taken in daily with the inspired air are
23 not so well defined, since they must always be calculated.
24 The quantities appear to range between .015 to .09 mg. per day
25 and as in the case of the intake in food, the average in any

1 situation is much nearer the low value than the high.

2 The maximum quantities of lead absorbed into the body
3 from that taken into here the alimentary and respiratory
4 tracts of the average man may be estimated on the basis of
5 experimental evidence which shows that somewhat less than
6 10 percent, of that ingested (swallowed) and somewhat less
7 than fifty percent, of that inhaled, are absorbed.

8 Calculations based on these percentages indicate that
9 about .03 mg may be absorbed daily from the alimentary tract,
10 while quantities ranging from .007 to .045 mg and averaging
11 between .02 and .03 may be absorbed daily from the respiratory
12 tract. As is clear from this there is less likelihood of the
13 absorption of lead day to day from the air, the quantity is
14 less, than the quantity which is likely to be absorbed from
15 the alimentary tract.

16 Therefore the food and drink side of this environmental
17 picture is still the more important side.

18 Evidence obtained by corresponding means has demonstrated
19 that the quantities of lead eliminated from the body daily by
20 the average man are substantially equivalent to those taken
21 in.

22 Thus the lead which is evacuated so with the feces,
23 daily, is only slightly less than that in the food and
24 beverages. That which is excreted in the urine ranges from
25 somewhat less than .01 mg to about .08 mg per day, and

1 averages approximately .03 mg per day. The total output of lead
2 in the feces and urine, over a period of months, usually
3 exceeds slightly the intake in the food and beverages, thereby
4 indicating, indirectly, that the magnitude of that absorbed in
5 the respiratory tract of persons investigated in Cincinnati
6 is not less than .03 mg per day.

7 Senator Muskie. Doctor, you have been giving us
8 figures that come from the Philadelphia studies?

9 Dr. Kehoe. No. These have come from very carefully carried
10 out, balanced experiments on human subjects in the Kettering
11 Laboratory.

12 Senator Muskie. As of what date?

13 Dr. Kehoe. Beginning in 1939 and extending to the
14 present time. They are still going on. What we undertook
15 to do back in this period, back in 1939, we gave up any hope
16 of understanding this problem unless we carried out balanced
17 experiments on human beings which told us the source of lead,
18 the manner in which they enter into the body, the manner
19 in which they get out of the body, and what is the relationship
20 between intake and output under ordinary normal conditions
21 and under conditions that exist in industry or whenever there
22 is an unusual exposure.

23 That has told us things about the physiology of the
24 behavior of lead in the human body that we could not have
25 learned by any other means.

1 Senator Muskie. The question I was getting at is
2 that since these studies extend over a period of two or
3 three decades do you have any data as to whether or not
4 the amount taken into the body each day has increased over
5 that period?

6 Dr. Kehoe. The evidence so far as Cincinnati is concerned
7 and our experimental subjects have been in Cincinnati in the
8 Kettering Laboratory -- this does not apply to other cities
9 specifically, in a general way it does -- the evidence is
10 that over the period of the last thirty years there has
11 been very little change, if any, but the change has been down-
12 ward, if any, rather than upward.

13 There has not been an increase in the intake of lead
14 by the citizens of Cincinnati as represented by our
15 experimental subjects.

16 Senator Muskie. What is the nature of the samplings
17 you take in Cincinnati?

18 Dr. Kehoe. The sampling is very meticulous. These
19 experimental subjects collect exact duplicates or nearly
20 as exact as can be obtained by intelligent young men, exact
21 duplicates of everything eaten and drunk during a period,
22 every item of food that passes their lips, every item of
23 drink including cocktails and coca cola must even be in
24 the duplicate sample for analysis.

25 These men also collect every sample of feces every day,

1 every drop of urine that is passed every day, and this is
2 subject to analysis day by day as the thing goes on so that
3 we have a day by day observation on experimental subjects
4 for as long as four and a half years.

5 Senator Muskie. With respect to intake, have you had
6 samples over that period, intake from the air as well as
7 intake --

8 Dr. Kehoe. We know what the content of lead in the
9 air in the Kettering Laboratory which in which these subjects
10 spend their day. We know also what is the lead content
11 of the atmosphere in which they live so that by calculation
12 we can get at this. It is quite fair to say that over the
13 period beginning in 1947 there has been little or no change
14 in the atmospheric conditions in respect to lead in
15 Cincinnati.

16 Here again if there has been a change there has been a
17 diminution.

18 Senator Muskie. You are talking about the lead content
19 in the air. How about the amount of lead that is taken
20 in from the air by human beings?

21 Dr. Kehoe. First of all we carried out experiments
22 that relate to the intake and output in the food and have
23 increased quantities taken by mouth. In 1949 we began
24 experiments on inhalation dealing with known concentrations
25 of lead in the atmosphere and following the intake and output

1 here of subjects that were in atmospheres, low levels and
2 in atmospheres that approached those of the industrial
3 situation.

4 One of the things we were most concerned about and have
5 been over the years is to get at the question of a standard
6 which can be applied to industry that will say certainly and
7 without any question of doubt whether the situation under
8 which a man works is safe or whether it is dangerous.

9 The differentiation of these two in industry is
10 absolutely imperative to industrial control. So that our
11 first work dealt with this in relation to industrial
12 exposure. It has for the last five years been concerned
13 specifically with lead of the order of magnitude of that
14 which occurs in the air or might conceivably at some time
15 be thought of as being potentially possible.

16 Senator Muskie. Have you taken samples from people who
17 have a particularly heavy exposure to lead in the air,
18 traffic policemen, service station attendants and so on?

19 Dr. Kehoe. Yes, we have done this systematically over
20 a period of a good many years. So there is a body of data
21 available on this matter in Cincinnati, a body of data that
22 has been published.

23 The information is available in these records -- since
24 the first information obtained by methods now in use so
25 that comparable data year to year were obtained in 1937 and

1 Senator Muskie. Is it your conclusion that in 1937
2 to the present time on the basis of that data that there has
3 been no increase in the amount of lead taken in from the
4 atmosphere by traffic policemen, by attendants at service
5 stations or by the average motorist?

6 Dr. Kehoe. There is not the slightest evidence that there
7 has been a change in this picture during this period of time.
8 Not the slightest.

9 Senator Muskie. Is there evidence that assures you that
10 there has been no change?

11 Dr. Kehoe. Evidence obtained in an effort to find the
12 one thing about it that we have been concerned about in this
13 situation and for a good many years have studied, is that there
14 might be somewhere sometime some combination of strange
15 circumstances that would put the lead content of the food
16 and drink high at the same time that the air was high and
17 that under these circumstances we might find an individual,
18 a group of individuals, or a population in a particular area
19 like that of an industry in which there was an undue
20 exposure and in which there would be real risk.

21 We have looked systematically for such groups for the
22 last fifteen years and we have failed utterly to find them.
23 This is why we began to study garage mechanics many years ago,
24 because of two things. First of all, the garage mechanic
25 in the very nature of his work has a heavier exposure to

1 the exhaust gas of automobiles than most people do, so much
2 so that a fair number of these men in cold weather go home
3 in the evening with carbon monoxide headache which means
4 exposure to exhaust gasoline.

5 These men however have an occupational exposure to lead
6 by virtue of the fact they do little body work, a little
7 body painting, a little repair work of a variety of kinds,
8 they handle greases, they sometimes do a certain amount of
9 real repair on storage batteries which are lead containing
10 and these men also get unconsciously dirty which we all
11 know.

12 They crawl around on the floor under automobiles. Their
13 clothes are dirty, their hands are dirty, they smoke
14 cigarettes, they eat sandwiches in their place of work. These
15 men do have an immeasurable exposure to lead which is demon-
16 strated quite clearly from the fact that these people are
17 differentiated from filling station employees, refinery
18 workmen, traffic policemen, postmen who pound the streets
19 and this sort of thing.

20 This group and this group only of the people that we
21 have looked at have shown a statistically different intake
22 and output of lead from the people in the general population.

23 This I may say is the mildest occupational exposure
24 that we have found in which there is a certain differentiation.
25 statistical differentiation in the intake and output of

1 lead and yet without lead poisoning. Lead poisoning in the
2 garage mechanic is essentially non-existent unless he
3 carries out a specific job that is known to be hazardous
4 over a long period of time consistently.

5 Senator Muskie. Over the past thirty years I assume
6 there has been a tremendous growth in automobiles and in the
7 amount of traffic in Cincinnati and yet as I understand it,
8 you say that there has been no increase in the concentration
9 of lead in the ambient area?

10 Dr. Kehoe. That is a fact.

11 Senator Muskie. Over that period of time?

12 Dr. Kehoe. This is a fact. There has been a change
13 downward, since the period of the Second World War when we had
14 difficulty in Cincinnati getting the kind of control we
15 would like to have and getting it burned in the way we would
16 like to have it and Cincinnati has a very large coal burning
17 industrial and household problem.

18 During this period we had to take the coal that
19 could be obtained and there was definitely an easy going
20 policy with respect to smoke abatement because of the times.

21 In 1945 this whole situation was changed and in the
22 period immediately following this the lead content of the
23 atmosphere of Cincinnati went significantly downward.

24 Senator Muskie. What you have just said is that the
25 decrease in the concentration in the atmosphere is due to

1 better control of stationary sources of air pollution?

2 Dr. Kehoe. That is right.

3 Senator Muskie. Do you draw any conclusions as to what
4 has happened to concentrations of air attributable to the
5 automobile over that period of time?

6 Dr. Kehoe. All this meant was that there was a significant
7 amount of the air pollution in Cincinnati yielding lead that
8 was due to the burning of coal which has about 14 to 16 to 20
9 parts per million in it, which creates a certain amount of
10 lead to the atmosphere.

11 Now since that time the concentration of lead in the
12 atmosphere which has been tested on several different
13 occasions in a very significant manner has been substantially
14 stationary. There has been a decrease in recent years as
15 it presumably as the consequence of changed patterns in
16 the traffic of Cincinnati, of loosening up the congestion
17 and getting a more peripheral traffic flow of automobiles.

18 The traffic in Cincinnati is definitely easier now
19 than it was, say five years ago.

20 Senator Muskie. Have you drawn any conclusions as to
21 whether or not the concentration of lead in the atmosphere
22 attributable to the automobile in Cincinnati has gone up,
23 gone down or remained stationary?

24 Dr. Kehoe. I would say from the evidence we have at
25 this point that it is a little risky to attribute much change

1 to that. What has occurred during this period of time has been
2 within the variability of day to day results.

3 Senator Muskie. So you have a conclusion?

4 Dr. Kehoe. We have a conclusion which says that has
5 not increased.

6 Senator Muskie. Let us see if we can generalize that
7 conclusion. Are you saying that the increase in the
8 automobile population of the United States has not in the past
9 and is not likely in the future, given the same quality of
10 gasolines that we now use, to increase the concentrations
11 of lead in the atmosphere?

12 Dr. Kehoe. I am not drawing any conclusion, Senator Muskie.

13 Senator Muskie. We have to draw the conclusion. From
14 what you have told us so far about Cincinnati's situation
15 that you believe that the automobile has not added to the
16 concentration of lead in Cincinnati air.

17 Now I am trying to find out what that means in terms
18 of the United States.

19 Dr. Kehoe. There would be no question in my mind that
20 if you could move a larger number of vehicles through the
21 American city, you would get more lead in the atmosphere.
22 But we have very nearly reached the point of stand still
23 in some of our cities.

24 Senator Muskie. I guess I have not driven in those cities.

25 Dr. Kehoe. In consequence of this in some of these

1 this has reached almost a stationary point. Certain areas
2 of Philadelphia, certain areas of Los Angeles, certain areas
3 of New York City.

4 Senator Muskie. It seems to me we are constantly
5 building highways that makes it possible for more automobiles
6 to go to the cities.

7 Dr. Kehoe. Yes. What this results in is a spreading out.

8 Senator Muskie. A spreading out but not a reduction
9 of automobiles in the city?

10 Dr. Kehoe. Nor does it mean a reduction in the total
11 lead content in the air. It means that the concentration
12 at particular points where there are people tends to be
13 more widely spread over the community so that the overall
14 concentration is lower than it would be when this reaches
15 this point of congestion which is almost impossible.

16 Senator Muskie. What you have said to me suggests
17 that the concentration in some places would be less and in
18 other places more?

19 Dr. Kehoe. You are quite right.

20 Senator Muskie. We are spreading it out.

21 Dr. Kehoe. You are quite right.

22 Senator Muskie. You seem to have emphasized the less
23 rather than the more.

24 Dr. Kehoe. No, I have not except that there is this
25 degree of variability and there is this approaching tendency,

1 I should say, in some of our urban centers to get a lower
2 distribution of a more consistent value from urban areas
3 to center.

4 Senator Muskie. What is the net result to the city?
5 Is it more lead or less lead? You talk about distribution
6 now. How about the net?

7 Mr. Kehoe. This may be more in the total air of
8 the community but this is less in those areas in which
9 previously it was higher where you find people. So that
10 from the point of view of the person who is exposed --

11 Senator Muskie. Yes, but Doctor, have you ever filled
12 an empty river basin? The lowest spots get filled up first
13 but eventually the high spots get reached. As the water goes
14 up it gets deep enough to drown people.

15 What you are saying is that in Cincinnati, presumably
16 in other cities, as traffic patterns change because of the
17 construction of new highways and so on it loosens up and
18 tends to spread it.

19 I am interested in whether or not the level is going up.
20 This is the question I have been driving at for the last
21 few minutes, whether or not your evidence in Cincinnati
22 indicates that the level is going up with the growth in the
23 automobile population.

24 I still don't have an answer that I can hang on to.

25 Dr. Kehoe. The level at a particular point up to the

1 present time has not gone consistently upward because
2 the effect on the population has not altered. This raises
3 the question of what will happen in the future. You don't
4 know and I don't know and nobody knows what will happen in
5 the future. This is the thing which has to be known.

6 Senator Muskie. This is a rather mathematical certainty,
7 if we have the same lead content in gasoline, that as the
8 number of automobiles goes up the amount of lead poured into
9 the atmosphere will go up.

10 Dr. Kehoe. In the total atmosphere, yes.

11 Senator Muskie. Yet the value of -- the value you have
12 given us with respect to Cincinnati suggests, as you have
13 presented it, that this is not inevitable?

14 Dr. Kehoe. It is not inevitable, no, if you change
15 the characteristics -- if, for example, you could bring more
16 air into this and sweep it out, the concentration would be
17 low.

18 Senator Muskie. How do you bring more air into the city?

19 Dr. Kehoe. I am not trying to do that. I say if you
20 could. This is hypothetical. If you could move the
21 air more rapidly it would get more rapidly diluted.

22 If you then distributed the vehicles so that
23 they are more widely and more uniformly distributed the high
24 results will come down, the lowest results will go up.

25 The question then will be what is the critical concentration

1 which becomes dangerous for any man anywhere?

2 Senator Muskie. With your chief maximum distribution then
3 the level will start to go up, or will it?

4 Dr. Kehoe. The level of the total atmosphere will go up
5 but what happens to it at any particular point depends on the
6 manner of its distribution.

7 Senator Muskie. So that with respect to Cincinnati
8 the conclusion must still be regarded as tentative and
9 inconclusive?

10 Dr. Kehoe. With respect to the future, yes.

11 Senator Muskie. It cannot be taken to justify any conclusi
12 as to any city, any other city?

13 Dr. Kehoe. Yes and no.

14 Senator Muskie. That is a very uncertain answer.

15 Dr. Kehoe. Well, what one deals with in this situation,
16 Mr. Muskie are the probabilities. The recent survey of
17 Philadelphia, Cincinnati and Los Angeles have shown so many
18 characteristics of this thing that are very nearly identical
19 that we have not a leg to stand on to believe at the present
20 time that any one of these is particularly unique in this
21 regard.

22 Senator Muskie. As to your testimony with respect
23 to Los Angeles, for example, now Los Angeles has done
24 a tremendously effective job of eliminating stationary
25 sources of pollution.

1 Yet our testimony just this week is that we have had
2 a recurrence of smog in Los Angeles because of the growth of
3 the automobile population notwithstanding the control of
4 stationary sources.

5 So, all of our evidence is in the testimony up to now is
6 that the automobiles are raising the level of pollutants
7 in the air. Now your testimony this morning is that we do
8 not need to expect that with respect to lead in Cincinnati
9 and now I am so asking you to try to generalize that with
10 respect to Los Angeles and other cities.

11 Dr. Kehoe. All right. There are spots in Los Angeles
12 at certain times of the year in which the values are relatively
13 high. When however these are looked at in a cross sectional
14 way the difference between Cincinnati and Los Angeles
15 is of the order of 1.4 in Cincinnati and to 2.2 or 3 in
16 Los Angeles.

17 Senator Muskie. I agree but that is not relevant
18 to my question.

19 Dr. Kehoe. I am trying.

20 Senator Muskie. The question is, can we expect again
21 the amount of lead in the atmosphere to go up as the
22 automobile population grows?

23 The evidence in Los Angeles is that pollution from
24 automobiles generally not specifically tied to lead is going
25 to go up. I am wondering if the lead is going to go up

1 with the rest of it.

2 Dr. Kehoe. I think it is very likely that it is. I think
3 where it goes up will depend on a number of circumstances
4 which would have to be investigated in order to give
5 you the answer.

6 What I have been saying in this, Mr. Muskie, quite
7 consistently for thirty years is that we must know what we
8 are talking about before we talk.

9 Senator Muskie. Now that is a point on which we can
10 agree. Dr. Prindle's testimony yesterday with reference to
11 the studies in Cincinnati, Philadelphia and Los Angeles,
12 included this statement "The average concentration of lead
13 in all samples collected in each city was 1.4 micrograms
14 per cubic meter of air, a microgram being a millionth of
15 a gram so these are very small amounts we are dealing with,
16 in Cincinnati 1.6, in Philadelphia and 2.5 in Los Angeles.
17 The samples taken in heavy vehicular traffic were considerably
18 higher. 14 micrograms per cubic meter in congested traffic
19 on Cincinnati streets, and 25 micrograms per cubic meter
20 on the Los Angeles Freeway."

21 Now let me ask you this question, Doctor. How do the
22 figure you have given us with respect to Cincinnati relate
23 to vehicular traffic as against outside of the vehicular
24 areas of the city?

25 Dr. Kehoe. Many of these observations that were made

1 with respect to vehicular traffic were made in Cincinnati
2 by our own group. Consequently the statement there is true.

3 The point of the thing with respect to human exposure
4 which is the big problem here is that there are really not
5 very many people who spend much of their life time on a freeway

6 They go to work and they return home but they don't
7 spend days on it except for certain individuals who drive
8 trucks, who drive delivery wagons who use these in the
9 course of their normal work and who therefore spend considerable
10 time on them.

11 These are the people we need to look at and these are
12 the people we have looked at.

13 Senator Muskie. Dr. Prindle yesterday and the Surgeon
14 General made a distinction between clinical effects from
15 exposure to lead as to which he felt there was a pretty good
16 body of data, and low level, subclinical exposure over long
17 periods of time as to which he said we have very unsatisfactory
18 data.

19 Now do your certainties on this point relate to both
20 kinds of exposure or both kinds of results?

21 Dr. Kehoe. yes, rather more I should say than either
22 Dr. Prindle or the Surgeon General. I am not accusing
23 them here of ignorance or drawing a long bow. These
24 gentlemen know this problem as well as I do and they are
25 concerned about it. The point of the thing is that we have

1 shown quite clearly in the industrial situation that if you
2 will lower the concentration of lead in the atmosphere
3 to a certain point, if you will prevent exposure of the
4 individual to a certain point you will not get lead poisoning.

5 Senator Muskie. How about these effects which both of
6 these doctors have clearly said they draw no conclusions
7 about they they say have not been established?

8 Dr. Kehoe. Mind you, I realize the difference between
9 the industrial population and the general population. Our
10 evidence comes very strongly from industrial population. If
11 you will maintain the conditions which we now describe as
12 being safe in industry, men continue to work in this industry
13 all their working lives and at no time do they develop lead
14 intoxication.

15 We have observations on personnel in industrial plants
16 now over a period of thirty years in which there has been
17 no case of poisoning, no shortening of life, no evidence
18 of any subclinical injury that we can detect in this
19 population as differentiated from a normal population, that
20 is to say a population working in the same kind of job
21 without lead.

22 Now this is not in the strictly scientific sense,
23 this is not absolute proof. But thirty years of observation
24 is pretty good evidence which I don't think one discards
25 readily.

1 Senator Muskie. Well, the committee cannot discard
2 readily the apparent conflict between your testimony and
3 that of the Surgeon General. So I want to be sure I understand
4 the difference in your points of view. As I understand
5 from your testimony you have suggested that up to a point
6 the accumulation of lead in the body is harmless?

7 Dr. Kehoe. That is right.

8 Senator Muskie. You draw the line just below the
9 lead poisoning?

10 Dr. Kehoe. Considerably below.

11 Senator Muskie. Does medical opinion agree that there
12 are no harmful effects and results from lead ingestion
13 below the level of lead poisoning?

14 Dr. Kehoe. I don't think that there would be a complete
15 agreement on this at the present time. I don't think that
16 many people would be as certain about this as I am at this
17 point.

18 Senator Muskie. But you are certain?

19 Dr. Kehoe. Not certain about it. I am only saying
20 these are the probabilities and we still have observations
21 yet to make. It so happens that I have had more experience
22 in this field than anybody else alive.

23 Senator Muskie. You agree that two men with the same
24 experience could disagree as to the conclusion?

25 Dr. Kehoe. I don't think there is any doubt among the

1 people who are experienced in the industrial situation,
2 I don't think there is any doubt at all, that if you meet
3 the criteria for safety that now exist in this relationship
4 you can confidently expect that you will have no cases of
5 lead poisoning. I am talking about none.

6 Senator Muskie. Let me repeat the question so that I can
7 be sure as to where your certainty lies. I asked does medical
8 opinion agree that there are no harmful results from lead
9 ingestion below the level of lead poisoning?

10 Dr. Kehoe. No, there is no consensus of opinion on
11 this point. There will not be for a long time to come.

12 Senator Muskie. Are you certain on that point, yourself?

13 Dr. Kehoe. It is entirely possible to postulate
14 that somewhere, sometime, within the universe of the
15 population, you will find individuals who are so especially
16 susceptible to lead that under the conditions that exist
17 in the rest of the population that these people will be singled
18 out and poisoned.

19 Senator Muskie. That is a pretty minimal risk as you
20 describe it. Does the medical profession as a whole regard
21 the risk as minimal as you do?

22 Dr. Kehoe. There are a very considerable body of
23 people at the present time who believe as I do on this.
24 These are people who have had experience with the
25 specific problem.

1 Senator Muskie. This -- in Dr. Prindle's statement
2 yesterday he said this "In the occupational health field
3 when blood levels reach point zero six milligrams per hundred
4 grams of blood the worker is normally removed from an
5 environment in which lead exposure can occur. Concentrations
6 .08 milligrams of lead or more per one hundred grams of blood
7 are associated with toxic lead poisoning, the clinical type
8 that Dr. Stewart described. I would point out the small
9 difference between .06 milligrams or six parts per ten million
10 and eight parts per ten million is not a very marked margin
11 of safety."

12 Would you agree with that?

13 Dr. Kehoe. I would agree with that. In a general way
14 I would agree with this is a small margin but in terms
15 of analytical methods that are available at the present time
16 this is not such a small margin that is insurmountable.

17 I have never seen one case of lead poisoning at the
18 onset in child or adult that has not had at least .08.
19 Now this does not mean that all people become ill at this
20 point. The majority do not -- only a few. This is the
21 lowest level of susceptibility in my experience.

22 Senator Muskie. Let me ask you this.

23 Is that kind of margin significant or would it
24 become significant if the concentration of lead in the
25 atmosphere were to double?

1 Dr. Kehoe. Yes, this margin would be quite adequate
2 for this reason and we have very good evidence for this.
3 If you double the concentration of lead in this that exists,
4 in the ambient atmosphere to which individuals are exposed,
5 you will get no material change in the concentration of lead
6 in their blood within two year's time.

7 Now you have a long time there before there is any
8 kind of build up that gives you this much difference. The
9 reason for this is that over the long period of time the most
10 of the lead that is absorbed into the body goes into the
11 skeleton.

12 Consequently the level of concentration in the blood
13 moves up very slowly. In our experiments over a period
14 of years we have seen that it takes four to six to eight
15 months to get a significant difference in the concentration of
16 lead in the blood and the excretion of the lead in the
17 urine if it -- if the dosage moves up slowly.

18 Senator Muskie. What is the significance from the
19 health standpoint of the concentration of lead in the bone?

20 Dr. Kehoe. This is not negligible but it is slight as
21 compared, for example, with the concentration of lead in
22 the brain. If you have a concentration of lead in the
23 brain, of the order of magnitude of 3/10ths of a milligram
24 per hundred grams, this is usually indicative of a
25 situation which is productive of fatal lead intoxication.

1 The bone has four times this concentration under perfectly
2 normal circumstances and conditions. You have this in your
3 body and I in mine at the present time.

4 Senator Muskie. Dr. Prindle had something to say on
5 this yesterday that I would like to get your reaction to.
6 The only way we can evaluate this testimony is to place it
7 side by side so that we can get the clash.

8 Dr. Kehoe. I can tell you for the record that you will
9 find very little difference between my views and those of
10 Dr. Prindle. Very little difference with respect to the
11 facts. There will be a little difference with respect to
12 considerations in the future, as is entirely appropriate.

13 Senator Muskie. His presentation of the facts and yours
14 at least give the impression of being substantially different.

15 Dr. Kehoe. But there really is not, sir.

16 Senator Muskie. I guess we will have to read those
17 more closely.

18 Dr. Kehoe. I know Dr. Prindle very well.

19 Senator Muskie. I think the testimony I was referring
20 to was in the Surgeon General's testimony rather than in
21 Dr. Prindle's testimony.

22 Dr. Kehoe. I think I could answer that question, sir,
23 without being presumptuous. What I think we are talking
24 about here are two different things. One of them is the
25 uncertainty with reference to what a material like lead might

1 ultimately do. As against the probabilities, which are
2 based on evidence, as to what it has done in fact.

3 From the point of view of the Public health we look with
4 considerable concern on any risk that is applied to the public
5 health. I may say we look with a great deal less concern, and
6 I think unfortunately, on the risk which is assumed by the
7 industrial worker.

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Senator Muskie. I can't find Dr. Stewart's prepared testimony but I have a discussion that took place between him and me on this question. This is the prepared testimony we have finally found:

'Evidence was also presented at the symposium which suggests another important respect in which the effects of lead may be largely overlooked because of limitations in our existing knowledge. This aspect of the problem stems from the fact that some of the lead taken into the human body is stored in the bones.

"Any of a number of factors -- including such physiological stresses as peptic ulcer involving excessive bleeding and such physical trauma as accidents in the home or on the highways -- may release lead previously held in storage. In such cases, the released lead may cause greater injury than the event which precipitated its release. Here again, the connection may never be made in the course of routine diagnosis and treatment."

I then asked him this question:

"You also say that the bones of the human body tend to store lead?

"The Surgeon General. That is right.

"Senator Muskie. Is there any doubt on this point?

"The Surgeon General. No, there is no doubt on that.

"Senator Muskie. If that is the fact, then the amount

1 of exposure which the human can take must be constantly
2 reduced?

3 "The Surgeon General. Well, the body reached an equilibrium
4 in the amount it is taking in and the amount that the body
5 is putting out, plus this storage factor. There is no solid
6 evidence that the storage factor, that the storage of lead
7 in the bones is itself harmful. Where I was making inference
8 here is that when that storage is suddenly released because
9 of some other event you suddenly have a lot of lead in the body
10 that is released from the storage in the bones, like a
11 fracture or like a severe bleeding.

12 "Senator Muskie. But the release is unpredictable?

13 "The Surgeon General. That is right, it is unpredictable.

14 "Senator Muskie. If it is unpredictable, you have to
15 assume, do you not, that the release will take place?

16 "The Surgeon General. I think so, given some event and
17 the release of the lead depends on how susceptible this
18 person is to lead intoxication."

19 How would you react to that point?

20 Dr. Kehoe. I would react very strongly to that, sir, by
21 saying that the thing which is feared here has not been seen to
22 occur. We are again talking about what may occur, and not what
23 has occurred. There is not the slightest evidence.

24 Senator Muskie. Which conclusion would you draw, that it
25 will or will not occur?

1 Dr. Kehoe. My conclusion is that lead in the concentrati
2 that has occurred in your skeleton and mine and in man in
3 generations ahead of us has never been known to produce lead
4 poisoning unless it was at highly elevated levels. We have
5 no evidence that this has ever occurred.

6 Senator Muskie. Why would the Surgeon General raise this
7 point?

8 Dr. Kehoe. Because there is in the literature a series
9 of experimental studies made a number of years ago that indi-
10 cated that under a variety of conditions lead is readily
11 released from the skeleton. I think, Senator, it has been
12 quite clearly demonstrated that this is not true.

13 Senator Muskie. You are satisfied that this is not true?

14 Dr. Kehoe. I am quite satisfied that it is not true.
15 In fact, I have never seen any situation of this sort reported
16 that to me was in any way plausible except in connection with
17 a disease of the kind that results in the virtual disintegrati
18 of the skeleton. Now I have been told by one of my pediatricia
19 friends in whom I have very considerable confidence that there
20 is a situation which has occurred occasionally in children.
21 I sought the evidence. I was unable to find it. He was
22 unable to find it. He still believes as he believes and I
23 still believe as I believe. What I am saying is that the
24 fragmentary evidence that is available in this field is much
25 too fragmentary to be trusted. I am sorry that the Surgeon Gen

1 said this because I have to flatly disagree with him and I
2 don't like to do it.

3 Senator Muskie. You say it is fragmentary, too fragmenta
4 to be trusted.

5 Dr. Kehoe. Yes, sir.

6 Senator Muskie. Is it too fragmentary to base a disagree
7 ment upon?

8 Dr. Kehoe. In my judgment, no. I am quite sure if the
9 Surgeon General was to read the literature in this field with
10 great care he would change his conclusion.

11 Senator Muskie. Maybe you ought to suggest that to him.

12 Dr. Kehoe. I have suggested it here. I think this will
13 probably come to his attention.

14 Senator Muskie. Speaking as a Senator now, you can't
15 rely on that.

16 Why don't you proceed, Doctor? I think I have asked all
17 the questions.

18 Dr. Kehoe. The facts obtained from these experiments and
19 from several field surveys have demonstrated clearly that the
20 quantity of lead which is being absorbed daily by the average
21 adult citizen of the United States who is not subjected to
22 occupational or otherwise unusual types of exposure to lead,
23 is balanced for all practical purposes by the excretion of a
24 corresponding quantity of lead. This balance is achieved within
25 the first several years of childhood (after the varied diet of

1 adult has been adopted) during which the levels of concentratio
2 of lead in the tissues of the new-born infant approach and
3 overtake those of the adult.

4 The newborn infant has some lead in the tissues. The
5 concentrations are quite low and they do not move upward until
6 later. They don't reach an equilibrium until the child is on
7 a full diet. Much of the highest concentration of this lead
8 (of the order of five times that in any other tissue) is found
9 in the skeleton. Moreover, the mass of the skeleton, relative
10 to the other tissues of the body, is such as to reduce the
11 concentration of such a minor constituent as lead, in the other
12 tissues, under ordinary circumstances, to almost negligible
13 proportions. It is not negligible since it can be measured
14 quantitatively. Indeed the concentration of lead in the
15 skeleton of the average child or man in the United States who
16 has not been subjected to any unusual exposure to lead, appears
17 to be of the order of 1 to 3 milligrams per 100 grams of
18 fresh, untreated bone, and this, when restated in the gross
19 relationships of the total weight of the lead contained in the
20 skeleton to the total weight of the skeleton, comes to the
21 average value of about 20 parts per million, which is not far
22 from the natural concentration of lead in soil and coal. This
23 gives you some idea of the relationship to the earth in which
24 we live.

25 So it is that the great proportion of the lead in the body

1 of the ordinary man is sequestered, in some degree, in that
2 part of the body that is least likely to be affected by it, and
3 is, in addition, in low concentration even there.

4 The Absorption and Excretion of Lead Under "Abnormal"
5 Conditions of Exposure:

6 The foregoing interpretation of the behavior of lead
7 taken into the body from ordinary sources is supported by the
8 facts observed when individuals have been subjected to the
9 absorption of quantities of lead beyond the range of those
10 which are encountered in ordinary life. Under such circumstanc
11 the rate of the excretion of lead in the urine varies primarily
12 with the current rate of the absorption of lead. The concentra
13 tion of lead in the blood also varies with the rate of the
14 absorption of lead, but is relatively slow in reflecting this
15 rate (unless the latter is very rapid). Instead, it tends to
16 represent the approximate state of the body generally, with
17 reference to its over-all burden of lead. Accordingly, if the
18 current rate of the absorption of lead is sufficiently high,
19 as compared to that which characterizes the usual pattern of
20 persons in the general population under ordinary environmental
21 conditions, there is an accumulation of lead in the tissues of
22 the body, including the blood, and the concentration of lead
23 in the blood mounts slowly to a point at which it is indicatie -
24 it does not absolutely give you the numbers but it is indicative
25 of the approximate quantity of lead accumulated in the entire

1 body.

2 Under the conditions of occupational exposure to lead, it
3 has been possible to develop sound criteria for the safety of
4 workmen, individually and collectively, which, when applied
5 scrupulously, result in the elimination of all cases of lead
6 poisoning. Stated in their simplest terms, these criteria
7 define the point in the absorption of lead, as revealed by the
8 general rate of the excretion of lead in the urine, and more
9 precisely by the concentration of lead in the blood, below which
10 cases of lead poisoning, even of the mildest type, do not occur.
11 The threshold value for the concentration of lead in the urine
12 is approximately 0.15 mg. per liter, while that in the blood is
13 0.08 mg. per 100 grams of whole blood. Allowance must be
14 made in both instances for the known error of the analytical
15 procedure employed, as well as for the range of the physiologic
16 variability of the results, which in the case of the urine is
17 appreciable but in the case of the blood is minute. Experience
18 has shown, however, that the criteria are reliable, and that
19 men employed in the lead trades remain free of any of the effects
20 of intoxication by lead, so long as they remain within these
21 limits with respect to their absorption of lead. Freedom from
22 intoxication by lead does not mean the mere avoidance of disabling
23 lead poisoning. Or as it has been spoken of, classical lead
24 intoxication, which is a term that might be used, but also
25 should be defined.

1 Rather, it means that no symptomatic or objective
2 evidence of intoxication can be detected, as such, by a skillful
3 and experienced physician. It has been suggested that any
4 single numerical limit such as this is most unusual in
5 connection with the toxic action of a chemical agent. To the
6 contrary, it is common, to the point of near regularity, that
7 there should be a minimum toxic, as well as a minimum lethal,
8 dose of a chemical agent. The point here, which has escaped
9 those who have not examined the facts, but have made loose
10 assumptions concerning them, is that the specified limits in
11 the concentration of lead in the urine or blood is not a point
12 above which cases of lead poisoning occur without fail. As a
13 matter of fact, there is no level of lead concentration in the
14 body which means certain lead poisoning but it is that point
15 in a range of values below which, regardless of human suscept-
16 ibility (so far as the present record holds), no case of lead
17 poisoning has been found, in our long experience, to occur.
18 The range of susceptibility, as this term is used in non-
19 specific medical parlance, extends from this point upward,
20 over a fairly wide range, but not downward. It is wholly in
21 keeping with the variability in the behavior of men, in
22 response to a great variety of stimuli or stresses, that there
23 should be limits within which the response is physiological,
24 and beyond which pathological manifestations occur with
25 increasing frequency and severity.

1 I would like to point out as an aside here that during
2 the entire history of man on this earth he has had lead in his
3 body. He has had lead in his food, he has had lead in his
4 drinking water and he has had lead in his body. This is
5 inescapable on this planet. The question is not per se whether
6 the lead is dangerous, but whether a certain concentration of
7 lead in his body is dangerous. This is the sole question,
8 physiologically.

9 The applicability of the foregoing criteria of safety from
10 the effects of the absorption of lead, especially that concerned
11 with the concentration of lead in the blood, within the
12 general field of environmental health is, of course, a crucial
13 matter in determining and controlling the risk incurred by our
14 population from the lead in their environment. It is because
15 this is the case, that the matter has been subjected to rigid
16 examination, with the result that, even in the case of infants
17 and very young children, the onset of lead poisoning has not
18 been found to occur in association with levels of lead concen-
19 tration in the blood under 0.08 mg. per 100 grams of whole
20 blood, with due regard to an analytical deviation of ± 0.01 mg.
21 per 100 grams, in the case of samples of the usual weight of 10
22 grams.

23 The critique which must be applied in the examination of
24 this matter must take into account the nature of lead poisoning,
25 and even more pertinently, at the moment, the opinions of

1 physicians and others concerning its nature -- those which have
2 been handed down among many generations of both critical and
3 uncritical physicians; those which had a sound basis in clinical
4 and experimental observation and judgment, and those which are
5 little more than "old wives tales." Without bringing all
6 aspects of this subject to definitive resolution, modern
7 physiological and biochemical investigation has exerted
8 a clarifying effect upon the toxicological concept of lead
9 poisoning, including certain of its more subtle or insidious
10 characteristics. At this time, therefore, it is especially
11 futile, other than as a stimulus for further extensions of
12 pharmacodynamic and metabolic investigation in the hands of
13 competent and imaginative physiologists, toxicologists,
14 pathologists and physicians, to cherish, in oneself or others,
15 a clairvoyant anticipation of unheralded and disastrous
16 effects of types hitherto unknown among trained observers.
17 Certainly, however, the concept of lead poisoning that must
18 be held in mind, now and in the future, must include all dis-
19 turbances in physiological function and in well-being that can
20 be attributed, on valid present or future evidence, to the
21 effects of lead.

22 Criteria of Public Safety with Respect to the Absorption
23 of Lead and Methods of Identifying a Threat to the Public:

24 As indicated previously, the opportunities afforded to
25 the average citizen of the United States (who is not subjected

1 to occupational or unusual types of exposure to lead) are
2 concerned with his ingestion (swallowing) and inhalation of
3 lead compounds which occur in his general environment. The
4 total quantity of lead that may be absorbed from these combined
5 sources constitutes the total threat, if any, of the environ-
6 ment, with respect to lead. However, since these sources
7 differ in their means and ease of penetration into the body,
8 and, to some slight extent at least, in their effect upon the
9 distribution and handling of lead in the body, they must be
10 examined, separately, as to their quantitative significance.
11 Accordingly, the limit of safety, with respect to the absorption
12 of lead from the one, that is, in the air, must be established
13 while the other is being held constant, that is, in the food,
14 and vice versa. This has been done, up to a point, in experiment
15 in the Kettering Laboratory.

16 (a) The upper safe limit of the daily intake of absorbable
17 lead into the alimentary tract

18 In one set of experiments, each of a series of human
19 subjects, after a period of observation of his daily intake of
20 lead in food and beverages, and his daily output of lead in the
21 feces and urine, (under basic conditions with respect to the
22 inhalation of lead from day to day), was given a measured
23 quantity of lead per day, one-third of it with each meal, in
24 simulation of his ingestion of food contaminated with lead.
25 These experiments have been described in some detail. In

1 brief, however, they have set up a criterion for human safety,
2 and have reported the results that meet this criterion. It
3 was evident that, under the conditions of these experiments
4 (in which about the same quantity of lead, the sum of that in
5 the food and beverages and that administered, was ingested each
6 day, for all practical purposes), each individual, to whom a
7 sufficient quantity of lead was administered daily, gave
8 evidence of the absorption of lead, in proportion to the dose
9 administered, and excreted lead in his urine at a steadily
10 increasing rate during the entire period of the administration
11 (for somewhat more than 4 years in one experiment). He also
12 developed an increase in the concentration of lead in his blood,
13 at a substantially uniform yearly rate, and accumulated lead in
14 his body (the cumulative difference between intake and output),
15 at a uniform yearly rate. No such effect was observed, however,
16 in the subject to whom the least dose, in addition to that in
17 his diet, was administered in 3 doses, each of which was 0.1
18 milligram. In this instance, there was a very slight increase
19 of borderline statistical significance in the output of lead in
20 the urine, no increase in the concentration of lead in the blood
21 and evidence (of borderline statistical significance) of the
22 accumulation of 12 mg. of lead in his body in the course of 1.5
23 year. This is believed to be as near the vanishing point of a
24 positive response as one is likely to obtain in an experiment
25 of this type. In consequence, it is probably that a young,

1 healthy adult -- I am not talking about the total population,
2 I am talking about a young healthy adult -- can ingest,
3 regularly, throughout his life, an average quantity of lead
4 of the order of 0.5 mg. per day, without any risk of accumulating
5 a significant quantity of lead, so long as there is no persistent
6 and significant increase in the intake of lead from the atmos-
7 phere. I might say, incidentally, this is not a wild guess.
8 There is evidence at the present time from the literature and
9 from the observations of Williams that this is about the level
10 at which England is taking in lead daily in food and beverages.
11 This may be a mistake because the information is indirect
12 rather than direct.

13 (b) The upper safe limit of the concentration of lead in
14 the ambient atmosphere

15 The experimental approach to the determination of the
16 safe limit for the inhalation of lead from the general
17 atmosphere differs from that concerned with the ingestion of
18 lead in food and beverages, the reason being that the quantity
19 of lead which is taken into the body with the air breathed,
20 as indicated previously, cannot be determined directly, but is
21 subject to calculation from the concentration in the air and
22 the volume of air breathed during a specified period of time.
23 A number of variables are involved in this calculation, so
24 that it can be carried out with a reasonable degree of accuracy
25 only under well controlled conditions, with respect to the

1 measurements of the lead in the air and of the volume of the
2 respired air. Then too, the quantity of lead absorbed in the
3 respiratory tract and lung varies with the rate and depth of
4 the respiration, as well as its volume, and, to an even greater
5 extent, with the dimensions, shape and solubility of the
6 particles of lead-bearing material that is being inhaled. The
7 most satisfactory physiological criterion, with respect to the
8 significance of the absorption of lead in the respiratory
9 apparatus, lies, therefore, in the response that is afforded
10 by the change in the content of lead in the urine and blood.
11 However, while analyses of the urine and, more effectively,
12 the blood, provide definitive evidence of the safety or the
13 potential risk of the individual (and of groups of individuals)
14 at the time of the analyses, they cannot yield information on
15 which to predict the probable extent of the absorption that
16 will occur ultimately, when lead is being absorbed into the
17 body at a constant, significant rate. As, for example, an
18 individual in the ambient atmosphere who breathes this atmos-
19 phere seven days a week and on indefinitely. This is a
20 different matter. This is the difference, and it is a funda-
21 mental physiological difference, between respiratory exposure
22 to lead according to the normal occupational schedule, now
23 standardized, generally, in the United States at 40 hours per
24 week, and that associated with lead in the atmosphere of the
25 community, which, although somewhat variable, from place to

1 place and time to time, is continuous throughout the day and
2 week. In the occupational situation, (and as simulated by
3 our experiments in which men were subjected to the inhalation
4 of a known compound of lead in a known state of subdivision
5 in the air -- nearly ideal for both retention in the lungs and
6 for absorption -- for approximately 40 hours per week), the
7 output of lead in the urine and its concentration in the blood
8 increase for some months until they reach a plateau the height
9 of which is determined, under uniform conditions, by the
10 concentration of lead in the air. Afterward, it remains
11 essentially unchanged, on the average, so long as the occu-
12 pational (or experimental) exposure continues unchanged. This
13 plateau is an expression of an equilibrium between the
14 absorption and excretion of lead, which is achieved by reaching
15 a balance between the periods of exposure, when absorption is
16 greater than excretion, and those out of exposure, when the
17 excretion is greater than the absorption.

18 There is no opportunity for the achievement of such a
19 balance when the rate of absorption is sustained, as in our
20 experiments during which lead was administered by mouth in
21 three doses through the day, and as it must be when lead-
22 bearing air, within appropriate limits of concentration, is
23 being breathed throughout the twenty-four hours of the days.
24 These facts make it necessary to approach the criterion of
25 the safety of the public, in relation to lead in the ambient

1 atmosphere, on a different principle than that of the safety
2 of employees in the lead-using industries. It is also
3 necessary to employ a different method of observation from
4 that concerned with the ingestion of lead, although the same
5 principle applies, that of establishing the largest daily
6 dosage of lead derived from the air which, when combined with
7 that derived from food and beverages, will be insufficient to
8 result in a measurable (or significant) accumulation of lead
9 in the body in the course of a life time.

10 We are talking here not about the accumulation up to
11 the point of toxicity. We are talking about whether there
12 is or is not accumulation. The latter is the criterion.

13 Experiments have been carried out in the Kettering
14 Laboratory for three of the past five years, by which the
15 methodology of the approach to this problem has been worked
16 out. During the past two years, two men have been under
17 observation, in accordance with these methods, while they have
18 been subjected to respiratory exposure to air containing a
19 low, uniform concentration of lead (Pb) on an increasing
20 schedule of hours per day during successive periods of 16
21 weeks. At the conclusion of this experiment, in early July
22 of 1966 -- one of the men is initiated but the other is not --
23 they will have spent almost half of their time in such an
24 atmosphere for 16 weeks. No definitive response to such
25 exposure has been observed, up to the present time, in the

1 form of a significant increase in the output of lead in the
2 urine or in the concentration of lead in the blood. Accordingl
3 in an experiment yet to be performed, the concentration of
4 lead in the respiratory chamber must be increased, and the
5 observations repeated. From all of these data -- those availab
6 and those to be obtained soon -- it will be possible to arrive
7 at a standard concentration of lead in the air as a physio-
8 logical criterion of public safety, in which a prudent margin
9 against chance may be incorporated. Needless to say, the
10 validity of the criterior should be put to practical test well
11 before the public shall have been subjected to the projected
12 level of exposure, by means of periodic surveys such as that
13 recently made, in which the reaction of the public to an
14 existing exposure of lesser magnitude can be determined.

15 Certain Basic Conclusions:

16 From the consideration of the observed facts and the
17 physiological principles developed in the foregoing statement,
18 it would appear that there is no reasonable basis for anxiety
19 concerning any potential threat that is offered to the public
20 from the lead in the ambient atmosphere in the United States.

21 Moreover, the means now available for the appraisal of the
22 severity of this type of exposure to lead, and of its hygienic
23 significance, would appear to provide ample safeguards in the
24 future, provided such means are employed skillfully and
25 critically, and frequently.

1 Senator Muskie. Doctor, I would like to read from a
2 couple of statements that were made at the symposium on lead
3 that was held by the Public Health Service last December.

4 Dr. Heineman said something that I think might be helpful
5 to us to place some of the points you made this morning in the
6 perspective that you would approve as well as the committee.

7 "The first thing I would like to point out is that there
8 has been no evidence that has ever come to my attention,
9 including at this meeting, that a little lead is good for you.
10 I say this because I believe there are some persons who imply
11 that this is so because of some of the statements which they
12 made. The second point I would like to make is that it is
13 extremely unusual in medical research that there is only one
14 small group in one place in the country in which research in
15 the specific area of knowledge is exclusively done. There
16 needs to be repetition and extension of the fine work which
17 has been done at the Kettering Laboratory with regard to
18 the metabolism and the balanced experiments which have been
19 done on lead. It needs to be repeated in many other places and
20 be extended. There needs to be in my opinion an extension and
21 improvement of the work which was done by the Public Health
22 Service in its tri-city study of lead body burden of people
23 in communities. There needs to be a careful study of the
24 figures I have given as the safe ones at which lead toxicity
25 will not probably occur. I say specifically.

1 "It is our experience in medicine that to use a single
2 figure as the safe one beyond which poisoning will probably
3 occur and below which poisoning will not occur is a most
4 unusual kind of situation in public health and in medicine.
5 I believe there needs to be careful study of the figures which
6 I used."

7 Would you want to react to that, Doctor?

8 Dr. Kehce. Yes. I believe first of all that the obser-
9 vations outside of those of the balanced work -- this
10 balanced work has not been done by anybody else up to the pres-
11 time. It may be that some of it should be repeated for the
12 sake of confirmation. It will be confirmed, I can assure you.
13 It may be that these experiments should be done in somewhat
14 the same manner. I should argue against that. I should argue
15 against that because first of all these are very expensive
16 experiments and they should not be carried out wrecklessly
17 without regard to the money that it takes to get this kind of
18 information. The methods that have been used in our obser-
19 vation which to me are crucial to this whole situation are
20 being used at the present time on a world-wide basis. They
21 have been used now over a period of years and there is simply
22 no question I think -- perhaps I am prejudiced, but I think
23 there is no question in the minds of a very considerable body
24 of experienced people in industrial hygiene that these results
25 are valid. They have been checked by experts in other countries

1 There is a report that is given here after a translation that
2 has been obtained, that was reported here, that was obtained
3 by our Swiss colleagues a matter of a few years ago who have
4 used substantially the same methods, who have followed out
5 comprehensive observations, I mean with respect to the field
6 surveys, and have come out with precisely the same results.

7 Now Heineman is right with respect to experiments that
8 are crucial, the methods that have been used in experiments
9 that have been checked by British investigators, by Swiss
10 investigators, by a number of others, as being the crucial
11 points in the determination of whether the information that had
12 been obtained in our observations was correct. This means only
13 one aspect that is left open and that is whether I, myself,
14 and my investigators in the Kettering Lab are clever enough
15 to be dishonest about this and get away with it. Frankly, I
16 don't think we have that kind of cleverness.

17 Senator Muskie. I don't think that question is involved.

18 Dr. Kehoe. It is theoretically, sir.

19 Senator Muskie. The only question involved is the inter-
20 pretation you place upon it. I will be frank to say that it
21 is unusual for me -- I am not a scientific man -- to find such
22 certainty in the field of scientific inquiry in a subject such
23 as this. The questions so far as we are concerned are one.
24 What are the effects, or do we know enough about them of
25 low-level sub-total exposure to lead in the atmosphere and,

1 secondly, how will the present answer to that question be
2 affected as the number of automobiles in this country and the
3 consumption of gasoline with lead content increases in the
4 future? These are the two questions we are concerned about.
5 On the question of the sub clinical effects, Dr. Hardy, who
6 testified earlier this morning, had this to say in the
7 symposium.

8 "I have to protest briefly that there is evidence of
9 lead related damage not identifiable as classic lead poisoning.
10 I have listed the following: Layne's Studies on Mortality
11 of Lead Workers. Henderson's Australian Work on the
12 Relationship Between Lead and Renal Disease. Doctor Jensen's
13 Work and, more modestly, mine, on the asymptomatic lead
14 workers, difficulty with his hemalogical abnormalities, and
15 then the large body of work on children without identifiable
16 lead poisoning who through well documented evidence have
17 experienced harmful lead effects either in" -- I am sure I
18 am not pronouncing these medical terms correctly -- "hemalogical
19 abnormalities or mental retardation." Doctor Hardy apparently,
20 and I might ask her to comment on this this morning, says
21 that there is evidence of sub-clinical effects that she feels
22 are of concern as relates to health. You apparently have
23 less doubt on that point.

24 Dr. Kehoe. No, I don't because I know that there are
25 effects that are residual effects of exposure that have had

1 here is not the residual effects of a one-time series of
2 exposures which do exist but the effects of a situation in
3 which we are at a very low level of intake, which has never
4 historically been known to result in a single case of illness
5 in child or adult. This is the difference in the thing.

6 We are not talking here about the residual effects of a
7 one-time intoxication. We are talking about whether signs
8 of intoxication come into existence under the conditions
9 that exist in the community at the present time. I submit
10 to you, sir, that there is not the slightest evidence that
11 that is the case in medical literature or in case material.

12 Senator Muskie. We are talking about a condition here --

13 Dr. Kehoe. We are talking about a condition which may
14 occur.

15 Senator Muskie. We are talking about something physically
16 that is occurring that may be producing a different situation.
17 We talk about growing concentrations of lead in the atmosphere
18 and what that may produce. This is a kind of low level, long-
19 term exposure that we have not had in the same degree in the
20 past, that we will have in an increasing degree in the future
21 given a continuation of the present methods of transportation
22 by automobiles and the present use of gasoline for fuel.

23 Dr. Kehoe. Let me put it this way. We have had experience
24 with the situation that exists at the present time, with
25 respect to the level of lead absorption in the American

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1 population. We have had experience with this over a period of
2 30 years or so during which we have been looking for problems
3 in the general population and have failed to find them.

4 Now, this does not tell us one thing about what will
5 happen five years, ten years, 15 years from now if, as and when
6 the concentration of lead in the atmosphere goes above a point
7 with which we have had previous experience.

8 Senator Muskie. That is bound to happen, is it not?

9 Dr. Kahoe. What I am prepared to say at this point is
10 that this is something which just like the food of the country
11 and the beverages of the country has to be watched, to make
12 sure that we know where we are. This will take time, this
13 will take trouble, this will probably continue and should
14 continue after I am no longer around to be looking at this
15 problem at all. But I can say very definitely that in my view
16 it is essential that these observations be made. We must know
17 and not have to guess about it.

18 Now I am only saying with respect to the things that
19 might happen that we have no experience of their happening and
20 I simply am not constituted to go on the basis, in the present
21 world in which we live, which is full of dangers, I am not so
22 constituted that I can be very anxious about a situation that
23 has been with us for 30 years and in which nothing has
24 happened, and which might conceivably happen, that ten years
25 from now something has to be different.

1 In the situation in which we are living at the present
2 time we are confronted with many dangers; the dangers of
3 contamination of the water of the country, the dangers of
4 contamination of the atmosphere with a variety of things are
5 much more imminent than this particular one. Whereas this
6 one must be investigated, it must be followed and we must
7 know what we are about, we have no reason at the present time
8 to fear what is under the bed somewhere.

9 Senator Muskie. Having listened to all your testimony,
10 Dr. Kehoe, I would say that that last pretty well summarizes
11 my impression of your position and I do appreciate your coming
12 and taking the time to listen to our questions and to answer
13 them.

14 The work of this committee is intended to be educational
15 for the committee as well as for the public. So we do appre-
16 ciate your contribution this morning.

17 Dr. Kehoe. Thank you.

18 Senator Muskie. I wonder if Dr. Hardy would be interested
19 in commenting upon the question that we just discussed.

20 Dr. Hardy. You read from my comments. That is really
21 the heart of what I have to offer.

22 Thank you.

23 Senator Muskie. Thank you very much.

24 The remaining two witnesses on our schedule this morning
25 have been kind enough to agree to come back next Tuesday

1 because of the time limitation this morning. I understand that
2 it will not be an inconvenience to either of them to do so. I
3 want to make sure of that. If it is not then Mr. Felix Wormser,
4 Consultant and Former President of the Lead Industries
5 Association, Inc., and Mr. Gammelgard of the American
6 Petroleum Institute, will be the first witnesses when we meet
7 next Tuesday at 9:30. I appreciate that courtesy very, very
8 much.

9 With that we will adjourn until next Tuesday at 9:30.

10 (Whereupon, at 12:40 p.m. the hearing adjourned, to
11 reconvene at 9:30 a.m., Tuesday, June 14, 1966.)
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