This transcript of the 1925 tetraethyl lead conference, held under the sponsorship of the U.S. Public Health Service, is an extraordinary document. The copy before you has been annotated with comments. Visitors pressed for time will find passages of varying interest marked with a green line at the beginning and a red line at the end. However a complete reading of the transcript would be time well spent.

The transcript shows that an appreciation of the dangers of lead far from being rudimentary in 1925 was quite sophisticated, although less from an experimental point of view than one based on observation, insight, and experience. As regards lead these qualities were probably much better developed in 1925 than they are today, since the spectrum of lead poisoning was much more in evidence then than it is now. If lead poisoning was to suddenly reappear unannounced at levels similar to those seen in 1925 it is doubtful that many today, even in the health profession, would know what they were looking at.

A principal player at this conference, Dr. Robert Kehoe, went on to become one of the most vilified individuals in the annals of public health, or medicine for that matter. Given the influence he wielded his denial that leaded gasoline (or lead in general) posed a danger to the public undoubtedly contributed to the poisoning of America. Even so, his coup-de-grace was yet to come. For beginning in the late '30s and ending in the early '70s', he ran a series of experiments where he fed lead to normal "volunteers", some of whom were on his staff, just to see what would happen.** Even by the standards of the day that had to have been an extraordinary event.

A failure to obtain the appropriate data was the Achilles heel of those opposed to adding lead to the nation's gasoline supply. Their collective wisdom, based on logic, insight, and anecdotal observations, was simply not enough to turn the tide. It is as true today as it was then that where big money is at stake only focused, objective, unbiased data, well presented and forcefully argued, have a hope of preventing harebrained and harmful ideas from being visited on the public. (contin. back of next page)

TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 158
AUGUST, 1925

Compliments of www.Bellsystemleadpoisoning.com

PROCEEDINGS OF A CONFERENCE DETERMINE WHETHER OR NOT THERE IS A PUBLIC HEALTH QUESTION IN THE MANUFACTURE, DISTRIBUTION, OR USE OF TETRAETHYL LEAD GASOLINE

PREPARED BY DIRECTION OF THE SURGEON GENERAL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1925

Throughout the transcript, blue comment ballons appear from time to time. Click on a ballon to read the comment.

After downloading the PDF files that make up this document visitors can merge the separate files into one using available software.

*** (results published in: Journal of Food and Chemical Toxicology; 25, 6; 1987.)*

TABLE OF CONTENTS

LIST OF ORGANIZATIONS, INDUSTRIAL AGENCIES, AND GOVERNMENT BUREAUS REPRESENTED AT THE CONFERENCE, WITH THE NAMES OF THEIR REPRESENTATIVES

American Federation of Labor:
A. L. Berres.
Mrs. Grace M. Burnham, *Director Workers' Health Bureau.*
Miss Harriet Silverman.
American Institute of Chemical Engineers:
Dr. D. E. Howe.
American Oil Co.:
John M. Klein.
Lee Sonneborn.
American Petroleum Institute:
Robert Welch.
F. B. Dow.
American Public Health Association:
Dr. Henry F. Vaughan.
J. A. Tobey.
Anglo-American Oil Co.:
H. S. Tegner.
Baltimore City Department of Health:
Dr. J. H. Shrader.
Barrett Co.:
S. R. Church.
Brown University:
Prof. C. A. Kraus.
Bureau of Chemistry:
Dr. C. A. Browne, *Chief.*
Dr. W. W. Skinner, *Assistant Chief.*
E. W. Schwartze.
Bureau of Labor Statistics:
Miss Whitney.
Bureau of Mines:
Dr. H. Foster Bain, *Director.*
Surg. R. R. Sayers (*detailed from the U. S. Public Health Service*).
C. A. Taylor.
Dr. W. J. McConnell.
William Yant.
Bureau of Standards:
Dr. H. C. Dickinson.
Doctor Thompson.
Carnegie Steel Co.:
B. M. Livezey.

Chemical Warfare Service:
Lieut. Col. Edward B. Vedder, M. C.
Cincinnati College of Medicine:
Dr. Robert A. Kehoe.
Columbia University:
Dr. Haven Emerson.
Dr. Frederick B. Flinn.
Department of the Interior:
Hon. Hubert Work, Secretary.
Deppé Motors Co.:
N. P. Deppé.
E. I. du Pont de Nemours & Co.:
Irenee du Pont.
W. F. Harrington.
Charles K. Weston.
Charles L. Reese (*President American Institute of Chemical Engineering*.
Dr. A. K. Smith.
Ethyl Gasoline Corporation:
W. Gilman Thompson (*Medical Consultant Standard Oil Co. of New Jersey*).
C. F. Kettering.
Thomas Midgley, jr.
Dr. Graham Edgar.
E. W. Webb.
A. W. Maxwell.
Federal Oil Board:
C. W. Waterman, *Manager*.
General Motors Corporation:
C. F. Kettering (*also with Ethyl Gasoline Corporation*).
Geological Survey:
Dr. George Otis Smith, *Director*.
Gulf Refining Co.:
Dr. W. A. Gruse (*of Mellon Institute*).
Harvard University:
Dr. Joseph C. Aub.
Dr. Cecil Drinker.
Dr. David Edsall.
Dr. Alice Hamilton.
Prof. Reid Hunt.
Johns Hopkins University:
Dr. W. H. Howell.
Dr. K. K. Marshall.
National Research Council:
Dr. Ludwig Hektoen.
Dr. E. W. Washburn.
National Safety Council:
Paul Frederick Stricker.
Navy Department, Bureau of Aeronautics:
Lieut. S. B. McMurrain.
New York Academy of Medicine:
Dr. E. H. L. Corwin.

New York City Department of Health:
Dr. J. A. Shears.
New York State Department of Health:
Dr. M. Nicoll, jr., *Commissioner of Health.*
Dr. Augustus Wadsworth.
New York, Reconstruction Hospital:
M. DeM. Touart, *Medical Director.*
Ohio State Department of Health:
Dr. E. R. Hayhurst.
Pennsylvania State Department of Labor and Industry:
Dr. Francis D. Patterson, *Chief of the Division of Hygiene and Engineering.*
Philadelphia City Department of Health:
Dr. William C. Robinson.
Standard Oil Co. of Indiana:
Dr. F. R. Morton, *Medical Director.*
Standard Oil Co. of New Jersey:
Dr. C. C. Johns.
E. M. Clark.
R. A. Van Eaton.
F. A. Howard.
State and Provincial Health Authorities:
Abel Wolman, of the Maryland State Health Department (*representing Dr. Johns S. Fulton, State Health Officer.*)
Steel Products Co., Cleveland, Ohio:
C. E. Thompson.
Studebaker Corporation:
A. J. Chanter.
E. J. Miles.
University of Pennsylvania:
Dr. H. F. Smith.
United States Tariff Commission:
Frank Talbot, of the Chemical Staff.
The Texas Co.:
Sherman Ford.
Yale University:
Dr. W. H. Haggard.
Dr. Yandell Henderson.
United States Public Health Service:
Surg. Gen. H. S. Cumming, *Chairman of Conference.*
Asst. Surg. Gen. A. M. Stimson.
Asst. Surg. Gen. J. D. Long.
Surg. L. R. Thompson.
Surg. G. W. McCoy.
Prof. William Mansfield Clark.
Prof. Carl Voegtlin.
Dr. H. D. Gibbs, Senior Chemist.

PROCEEDINGS OF A CONFERENCE TO DETERMINE WHETHER OR NOT THERE IS A PUBLIC HEALTH QUESTION IN THE MANUFACTURE, DISTRIBUTION, OR USE OF TETRAETHYL LEAD GASOLINE

The meeting was called to order at 10 a. m., May 20, 1925, at the Bureau of the United States Public Health Service (Butler Building, Third and B Streets SE.), Washington, D. C., by Surg. Gen. H. S. Cumming, presiding.

The CHAIRMAN. I will ask the meeting to come to order. I wish to introduce to you Assistant Secretary of the Treasury McKenzie Moss, who will open the conference.

Mr. MOSS. Ladies and gentlemen, I think I was born with too much sense to endeavor to discuss the questions which will be before you for determination, or even to endeavor to state the issues. I do not know that I would be able even to pronounce some of the words contained in the title. I am merely here to extend, on behalf of the secretary, a welcome to you and to express the confident belief that around this council table you gentlemen will be able to bring to a fair settlement and solution the problems which have brought you together. That is my mission and it has been performed.

The CHAIRMAN. Ladies and gentlemen, I take pleasure in introducing to you Secretary Work, former president of the American Medical Association.

Secretary WORK. Surg. Gen. Cumming and gentlemen of the conference, the applause that followed Secretary Moss's address was partly due, perhaps, to the brevity of it, so I will take notice and be equally brief. This conference has very much to consider from different angles. I became interested in it first from the viewpoint of public health. If this new agent, which it is proposed shall go into general use in every car, is prejudicial to health we should know it and the public should know it. I am interested in it also because of my present position in association with the Bureau of Mines, which is a scientific bureau, as you know. The Bureau of Mines has been making a careful experimental study in this line for several months. A few months ago they put out a statement which was accepted as final. It was not intended to be final. It was really a progress report. Since that time the bureau has been pursuing these studies in the same general direction, and they will lay before you the results of these studies. This matter that you are called together to discuss, is, I think, a very important one—one of the most important questions up before the public to-day. It has an economic bearing, possibly has a health bearing, and its commercial relations may be very extensive, indeed.

This is largely conjecture. None of us knows much about it as yet, so the purpose of this conference is very important, and your deliberations will take, I assume, some days. I can spend only a moment with you, but I am pleased to have had the opportunity to express my appreciation of your assembling here to discuss this question.

The CHAIRMAN. First, I want to express my appreciation to those gentlemen who have accepted an invitation to come to this conference. It is unnecessary for me to enter into any detailed explanation as to the purpose for which you have been asked to come together or the importance of the outcome of the conference. It is, however, perhaps advisable to say a word in the beginning as to the reason for inviting you to a conference and the object which we hope to gain as a result of your advice and counsel.

The Public Health Service, particularly through its division which has to do with the study of problems relating to industrial medicine, has long been interested in lead poisoning in the industries and has made some investigations along this line. We were therefore interested two years ago when we learned that one of the large corporations in this country in its endeavor to increase the efficiency of fuel used in internal combustion engines was experimenting with certain lead compounds to be used in commercial gasoline.

A little later on the question of an investigation as to the effect of these compounds came up, and after a conference with representatives of the Bureau of Mines it was determined, in view of the fact that the Public Health Service had no funds available for the purpose, that the investigation should be made by the Bureau of Mines.

Early in the winter I received letters from several gentlemen who had been interested in the matter, inviting attention to the potential dangers in the general use of tetraethyl lead and suggesting that a conference be called to consider the matter. After correspondence with everyone engaged in such investigations, so far as we could ascertain, it was determined that a conference at that time would be somewhat premature in view of the fact that none of the investigations had been completed.

Upon completion of the preliminary report of the Bureau of Mines, and after a conference with Doctor Sayers and the staff of the Hygienic Laboratory, I decided that it would be advisable to hold a conference as soon as practicable, and found that the report of the medical committee working at Columbia University, together with

other reports, would be available about the middle of May. I therefore took the liberty of requesting you to be present at this time. It seems unnecessary to inform you that this is in no sense a legal hearing; in fact, there are no Federal laws which authorize the Public Health Service to take jurisdiction regarding the interstate shipment of substances such as tetraethyl lead, even should it be determined that they are injurious to public health. On the other hand, it is the duty of the Public Health Service to investigate such questions and to inform the public as to the result of its investigations, restrictive measures being part of the police power of the several States and municipalities. However, I am quite certain, from assurances given both to me and to the public, that no police measures will be necessary in the premises should the use of tetraethyl lead be determined to be detrimental to the public health.

It is earnestly desired that we shall confine our conference as nearly as possible to the determination of such facts and to the reporting of such investigations and experiences as may lead to a definite determination as to the hazards, if any, which follow the manufacture, distribution, and use of tetraethyl lead and similar substances, not only to those who are engaged in the manufacture and distribution of the compound, but, more particularly, perhaps from my standpoint, to the public at large. The Public Health Service asks your cooperation in arriving at the proper solution of the problems.

I fully realize the responsibility imposed and the confidence that has been given to me, and I am quite sure you are all going to help me and help each other arrive at a solution of this problem.

I am sorry that we are not all around a small table. In our first study we had the advantage of the psychology of sitting around a conference table—we have grown a little larger than any available table—but I hope you will feel you are around a common council board.

I have thought it would be interesting, at least to some of us, if we begin this conference by asking someone to give us the history of the development of this tetraethyl lead in its relations to gas engines, and Mr. Kettering, the president of the Ethyl Gasoline Corporation, will give us the historical account.

Before he does so, may I say that I thought we would all be interested in seeing the working of one of the engines at a proper time. That will be demonstrated to you later.

MR. C. F. KETTERING

President, Ethyl Gasoline Corporation

Mr. Chairman, ladies and gentlemen, about 1914 we undertook to determine what were the essential factors in an internal-combustion engine which prevented us from getting more economy. As you perhaps know, it is possible to build internal-combustion engines which, when at full load, show very good percentage of efficiency. That has been pushed up to as high as 30 per cent, but inasmuch as in the automobile we very seldom drive at anything but a very small portion of the load, the efficiency falls off quite markedly with a decrease in the load. We undertook to study why it was, or what could be done that would assist in giving us more efficiency at the point where the public drive their cars.

We are getting to-day about 5 per cent of the energy out of gasoline; 95 per cent of it is thrown away. As I said before, it is possible, however, to push up on full load so that with the airplane engine or the motor-boat engine, we obtain up to a maximum of 30 per cent, and you can get fairly normal operation at around 20 per cent.

In that study there were a great many problems brought out because the instrumentation that was necessary to make these determinations had not been thoroughly developed, so we were confronted as we went along with continually having to stop our work on the actual study in order to develop instruments whereby we could make determinations that would have an actual quantitative value. There was as a rule abundant qualitative information about this, but none of it had been reduced to a quantitative basis.

After a preliminary study we discovered that with the fuels, as they now exist, one of the things necessary was to increase the compression of the motor. To explain what that is, I will say this: In the ordinary automobile motor as we have it to-day, and we will consider just a single-cylinder engine, here is the way the thing works. There is a cylinder in which is fitted a piston and there are two valves in that cylinder. We will say that our engine is standing still. The piston moves down, and as it moves down a valve opens which allows a mixture of gasoline and air to flow into that cylinder. That valve then closes, the piston goes up and compresses that mixture until it reaches nearly top center, then a spark is introduced into it and the mixture burns and an explosion of the gas is obtained; near the bottom of the stroke the other valve is opened and when the piston goes up those exhaust gases are ejected, save what was in the space above the piston. That thing is repeated. In other words, a cylinder in the ordinary gas engine, as it is known in the automobile to-day, gives you one explosion for every two revolutions, the

sequence being, first, a drawing in of the mixture; second, a compression of it; third, a firing and expansion of it; and fourth, an exhalation, and that is the way they got the term, "a 4-cycle motor," a cycle being the passing of the piston once over the cylinder.

Now the amount of the exhaust gas which is retained in the cylinder is the function entirely of that space which is above the piston, so that when you have a full load or a full charge in this engine, the per cent of the mixture which is retained in the engine is relatively small compared with the total amount taken in, but when you are taking only a little bit of mixture in, as for a quarter or half load of the engine, that dilution factor becomes relatively large. So it is desirable to cut the space down above the piston, and that is what, in engineering technology, we call raising the compression. In other words, it is simply reducing the space into which that mixture is compressed just previous to firing.

There are two or three factors which obtain when you raise the compression—two or three things which happen. First of all, you get a better burning efficiency; second, the dilution factor is reduced because the amount of exhaust gas which is retained there is smaller; and third, there is a smaller amount of surface exposed to the very hot gases at the time of combustion; so you gain in three different factors by raising the compression.

In the Diesel engine—this is simply by way of explanation—its result is accomplished not by taking the mixture into the cylinder in the way we do in the ordinary gas engine but by taking in the air and then compressing it; and then, after it has reached compression, the fuel is put into the engine at the definite rate at which it is to be burned. That is a differentiation from the ordinary automobile engine in that we take into the cylinder both the gasoline and the air, and they are compressed together, so that the Diesel engine has accomplished the raising of compression by keeping the fuel out of the mixture before you want it to burn.

Any attempt we were able to make to raise the compression was always accompanied by a corresponding gain in efficiency, but it was not accepted by the public because of the fact that when you tried to use the engine at full load you got what we call a "knock." That is the familiar sound known to everybody who drives an automobile when he tries to climb a hill. He gets a little carbon in the motor. In other words, we could not supply to the public the gain possible by engine alterations because of that very undesirable knock, and it was undesirable from two standpoints, first, because it might cause injury to the motor, and second, because the driver thinks there is something wrong with his motor. Therefore it was noncommercial from that standpoint.

So, after we had developed the possibilities of what might be done by the use of increase in engine efficiency, we then attacked the problem of whether we could introduce anything into the fuel which would stop this knocking. At that time none of us had any very definite knowledge of what was happening to such an engine. I do not know that to-day we know definitely what happens. In other words, we have found that those things like combustion, things we have known about the longest, the simple burning of a fuel and air, explained so simply, still have a lot of very technical things related to them, and are not as simple as the words might indicate.

At this point we developed quite a number of instruments which helped us to determine to a certain extent what was happening physically inside the engine cylinder. We found out that with ordinary natural gas we could produce certain results and with the higher-gravity gasolines, the aromatic series of compounds, alcohols, etc., we could get the high compression without the knock, but in the great volume of fuel of the paraffin series we could not do that. But we did prove that if we could use the motor at those compressions our efficiencies could be very greatly increased. So we started to try different materials which might, if put into the fuel, produce the desired results.

One of the first things that we used, and which has always been regarded as a sort of bench mark from which we reckon, is ordinary iodine, which when added to the fuel will completely stop the knocking. By way of explaining what the knock is, it has been proved by experiments in this country and abroad that the normal rate of burning of gasoline and air can proceed at quite different rates and that if the ordinarily efficient work be represented by 1 these rates are some place between sixty and seventy times as high, so that the change of rate is very much greater; in other words, sixty or seventy times greater; that the rate of burning is so rapid that the temperature goes very high, the radiation is very high. I might explain at this point that when we got to those very high pressures and to those very high temperatures the radiation rate from the flame is exceedingly great, and inasmuch as radiation can pass entirely through those gases without doing any heating it does not do a bit of work. It is just like having the mixture full of holes; and the radiation does no work until it strikes the cylinder wall and heats it.

After introducing the iodine we were first of the impression that perhaps it was the color added to the fuel that did something, because we felt that perhaps the color of the fuel did something in the way of absorption of radiant energy, very much as the early plants paint themselves red on the underside to absorb radiation and help their growth, but we disproved that supposition by using some

forms of iodine which are colorless. We found it was purely a molecular proposition and had nothing to do with the color, and we also demonstrated it by the use of some other colored materials that supplied the color but did not produce the other results. So finally we had this one material which we could introduce, which was a starting point from which we could make comparisons.

It took about 3 per cent iodine to be equivalent to 40 per cent benzol, and our methods of rating gasoline have been based on this line. We were taking a certain standard gasoline and adding 40 per cent benzol to it. That permits a certain raising of compression and a certain operation of the motor. We accepted that as a standard of compressions. Of course, iodine was out of the question from a commercial standpoint because of its not being obtainable.

Another very interesting thing in the use of benzol, or of iodine, was that it helped to produce carbon. So your cylinder would fill up very quickly with a very flaky type of carbon. I mention the word carbon. In the ordinary garage they will say, "Get the carbon cleaned out of your motor." The reason for that is that the carbon is one of the best heat insulators we have.

A small cake of carbon on the inside of the motor takes up space, it raises compression, and it slows the conduction of heat from the residual gases to the cylinder wall, and the difference between a satisfactory burn and an abnormal burn is very delicate when it comes to the point of temperature. A few degrees plus or minus will throw the thing from a satisfactory operation to an impossible operation.

I have seen that tried out on airplane motors, and it is rather interesting. Take a motor and a fuel condition which you can make normal; get up in the air and level off, fly along definitely, and finally open your throttle to a point where you ought to get an abnormal rate of burn. You go along and you get one detonation. I use the word detonation because that expresses the idea; whether it carries along the scientific factors of detonation we do not know, because it is purely a question of degree. You might get one detonation, in 15 seconds another, and in a very short period of time your motor will be detonating completely, and you will have to come down. Once you get one detonation in the cylinder you immediately throw a large quantity of the heat of the explosion, by radiation of energy, into the cylinder walls and heat them. With the next compression it gets hotter, and you get more heat into your cooling waters; it gradually rises in temperature and you pass from a normal to an abnormal operation on an apparently slight change in the thermal condition of the motor.

We then made a search of various other chemical compounds, and found aniline had a similar effect. We did a great deal of work on aniline and its kindred compounds. It took about 2 per cent of aniline to obtain the same results that 3 per cent of iodine gave.

There were many objections to aniline; the principal one was that it can not be obtained in quantities. We had been investigating a great many compounds and making a study of the physical chemistry of these problems, so that we might know what the factors were that we were dealing with. We tried one of the selenium metallo-organic compounds. We found that was an antiknock. We tried various other selenium compounds and tellurium compounds, and we finally took the atomic weights of the elements and went over the thing systematically. We found that while there are compounds which you can add to gasoline to stop its detonation, there are other compounds you can add that make it worse. If some surface above the top of this table be represented as zero, and if you put a pin to represent each element showing its value as an antiknock, the heads of the pins will lie on a warped surface, representing the antiknock potentialities of each element in its various valences.

These results tended to show that elements of high atomic weight were most effective as antiknocks, and almost as a last resort we started to study the properties of lead.

We tried for a long time to produce various organic lead compounds which would be soluble in gasoline. We did that without very much success, and finally, after a long period of time, we are able to get the tetraethyl lead compounds which are soluble in gasoline. When we tried those out we naturally had the factor of around 2 or 3 per cent in our minds, so when we got a small quantity of these we put it in a gasoline in the same proportion we had been dealing with. There was no indication of a knock. We kept diluting it and found that we were dealing with a material requiring only about one-thirteenth of 1 per cent. In other words, it was about forty or fifty times more effective than anything we had ever dealt with.

We then started a long series of road tests, after we had learned to mix small quantities of this material, and converted a few motors into the type of motor that could be operated with this fuel. We had a great many practical dufficulties, due to the fact that the lead burns to lead oxide, and that, deposited on the spark plug, fuses, lead oxide being a good flux for the porcelain and electrodes of the spark plug, which are of nickel. We tried various ingredients with the lead compound and finally used the bromine compounds, ethyl dibromide. The lead burns to lead bromine, and it does not stick on the valve but passes out of the motor.

That is really the high-spot history of this study. Up to this time we have not done anything on the motor for the reason that we were repeating tests to determine whether we could take out of

the fuel the characteristics which prevented us from decreasing the space above the piston. We have gone back and checked and rechecked many times the mechanics of this thing.

Briefly stated, here is where the economic phase of the thing comes in. As you increase the compression you get a higher gain in efficiency at the partial loads or driving speeds of the motor, and it is possible for us to-day to build motors that will give us at least 50 per cent increase in efficiency, and I do not think it is at all out of the range of good engineering to double the economy of gasoline.

That is the problem which we are working at entirely from the economics of the situation, recognizing that to-day with the enormous increase in automobiles, we will use 12,000,000,000 gallons of gasoline this year and 15,000,000,000 next year, and at the increasing rate we have *got* to do one of two things: We must build motors which are more efficient—we must build motors of very much smaller size and sacrifice a great many factors which we now enjoy in the motor industry, or we must do something which will allow us to get more work out of the fuel unit. Now, in regard to the building of such motors, there is nothing of a patentable or unknown thing in the building of higher efficiency motors. Our neighbors on the other side a few years ago built high compression, relatively high efficiency motors, because we shipped to them a better grade of gasoline than we use in this country. They did not have tank wagons and, therefore, we shipped the gasoline over there in tins, and, with the increased cost, it made very little difference whether they bought gasoline of 2 or 3 or 4 cents lower grade or higher. Consequently, they use a higher grade of gasoline in our export machines, and a great many times we have had letters saying, "Why don't you go to Europe and buy European machines and bring them over here and try them out?" We have done that very consistently, and have never been able to drive them under American conditions with American gasoline.

Looking at it entirely from the economy standpoint, so far as our research goes in 10 to 12 years, we know of no way of getting increased efficiency other than changing the compression or redesigning motors from many standpoints. The automotive art to-day knows enough to design motors to take a better fuel, but it is handicapped because it has not been able to do it.

In the introduction of so-called ethyl gasoline on the market we recognize that there were many factors in its marketing that we did not know. We recognized that we would have to get a distribution method for fuel before changes in motor design would be effective.

That briefly states the history and purely economic phases of the situation. We have been interested in it from the motor industry