AUTOMOTIVE RESEARCH AND DEVELOPMENT AND FUEL ECONOMY

HEARINGS

BEFORE THE

COMMITTEE ON COMMERCE
UNITED STATES SENATE

NINETY-THIRD CONGRESS

FIRST SESSION

ON

S. 1055

TO AUTHORIZE A PROGRAM OF RESEARCH AND DEVELOPMENT OF ALTERNATIVE PROPULSION SYSTEMS FOR AUTOMOTIVE VEHICLES IN COMMERCE

S. 1903

TO REGULATE COMMERCE AND CONSERVE GASOLINE BY IMPROVING MOTOR VEHICLE FUEL ECONOMY, AND FOR OTHER PURPOSES

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Mr. DUTCHER. I hope so. I think this is what is in it, you might say, for the California Legislature. As you know, the California standards for 1975 are considerably more lenient than the Federal standards. This is the first time California has found itself lagging behind the Federal Government in this matter. I have high hopes that, based on what we will be delivering to them, they will then make their standards not only equal to the 1975–76 Federal standards but I hope more stringent.

As you know well, California has a special problem. L.A. is the one place in the country where the culprit has been isolated. Ninety-two percent of the air pollution in the L.A. basin is caused by cars. In New York City possibly less than half of the total is caused by cars. But in L.A. they have gotten rid of every other source of pollution. You can't even burn leaves in your back yard in Beverly Hills. So the car is it. And you know how bad the air is. School children have to be kept in many days of the year. Can't go out and play, that sort of thing.

Senator TUNNEY. We are talking in California, of around 12 to 14 million vehicles on the road, are we not?

Mr. DUTCHER. Yes.

Senator TUNNEY. I would assume that means sales of around a million or a million and a half vehicles a year.

Mr. DUTCHER. Yes.

Senator TUNNEY. Assuming that the California Legislature did tighten up the standards considerably, there is no way that any company—your company, for instance—could produce the number of cars that would be needed to give to potential purchasers a locomotion system, and so it would mean that the major automotive manufacturers would be required to get into the act if they wanted to sell cars in California.

Mr. DUTCHER. Correct.

Senator TUNNEY. Have you had any discussions with the legislature, the decision-makers in the legislature, on this particular matter?

Mr. DUTCHER. Yes, I have. I have a feeling that most of the cars of the future, no matter how they are propelled, will be made in Detroit. On the other hand, if Detroit lags too far behind in this process, you and I know what the California Senate did in a frivolous moment about 3 years ago. They passed a bill banning the internal combustion engine, or really the sale of it, after January 1, 1975 in the State of California.

Since this is the biggest single automotive market in the world, it caused a great deal of turmoil in Detroit. The cooler heads prevailed the next day in the Assembly and the bill didn't pass. But the Califonria Legislature means business. They have the public behind them. I believe that whatever the California Legislature does in the future, if this automotive giant is going to be pushed around, it will be pushed around from Sacramento.

Senator TUNNEY. Would retrofitting of existing cars with your steam engine be viable in the future?

Mr. DUTCHER. Senator, I don't think so. I know Mr. Lear said that he thought it might be, and maybe it would. But my feeling is that by 1977, 1978, 1979, when let's say steam cars could begin to be

introduced in large numbers, the vast majority of cars on the road will still be large automobiles.

Henry Ford II appeared on TV last Sunday and admitted that his own company will still be making 50 percent or more of large vehicles right up through 1976. They have no plans to increase the present fraction of small compact cars they are making.

By that time, you will have probably over a hundred million large cars on the highways. I wouldn't want to retrofit them even if it could be done feasibly. I suppose anything can be done. However, it would be expensive, and you would still have these enormous cars. They would still, in order to get out of their own way, need large propulsion systems. I think the car of the future is going to be small, however it is propelled.

So I think a steam car or any other alternate vehicle will have to be built from the ground up.

Senator TUNNEY. Thank you very much, Mr. Dutcher. I appreciate your testimony. You have given us some really excellent insights into what you are doing, as a person who is interested in putting up his own money to achieve a most desirable result, and you have also given us some good insight into what the California Legislature is prepared to do.

I just hope that we can get legislation that is before this committee through the Congress so at the Federal level we could play our part, because it does seem to me from what I have heard this morning and what I have read in the past, including the National Academy of Sciences' statement, a report that was published on February 15, that the automotive industry is wedded to the internal combustion engine, they are wedded to the catalytic converters, of which the National Academy of Sciences says it is going to cost the American consumer $23 billion a year additionally, and there is just a great need to develop an alternative source of propulsion for vehicles, and men such as yourself, who are willing to put up your own money and who are willing to take a chance are really an incredibly valuable resource to the Nation, as has also been the case with private enterprise. Thank you very much.

Mr. DUTCHER. Thank you, Senator.

Senator TUNNEY. Our next witness is Mr. J. W. Carter, president of Texas Reinforced Plastics from Burkburnett, Tex.

STATEMENT OF J. W. CARTER, JR., PRESIDENT, TEXAS REINFORCED PLASTICS, INC., BURKBURNETT, TEX.; ACCOMPANIED BY J. W. CARTER, SR.

Mr. CARTER, Jr. My name is J. Carter, Jr. This is my father, J. Carter, Sr. He is the president of Texas Reinforced Plastics. It is a medium sized research and development company that is completely supported by their patents and their research and development work, and my father has been a consultant engineer on our steam project now for 5 years and has been a tremendous asset. I consider my father to be one of the smartest engineers I have ever met.

Senator TUNNEY. It is nice that your father is sitting here to hear you say that.

Mr. CARTER, Jr. Yes. We started on our project about 5 years ago, and we are completely self-supported. We have been financed by independent financiers.

Five years ago we started work, our first effort was for a low emission, high efficient alternative to the IC engine. Our first effort was toward the engine, a high efficient, low cost engine.

In doing this, we had to do several new things which had never been done before in order to achieve this efficient engine. We hope to achieve an engine which approaches the ideal cycle efficiency. In doing so, we are operating on 2,000 pounds per square inch pressure at 1,000 degrees Fahrenheit. The 2,000 pounds per square inch pressure is twice as high as any pressure that I know of in any reciprocating steam engine.

We also elected to use a reciprocating engine design. The reciprocating engine for horsepowers less than 500 is the most efficient expander. We also had to develop a valve system which would allow a small amount of high pressure, high temperature steam to be emitted to the top of the piston and then shut off and this high pressure/high temperature steam then expands the full amount and extracts as much of the energy as possible from the steam before it is exhausted.

In order to do this, we had to develop a valve that was capable of the high temperature, high pressures, had to be able to operate without any lubrication since it is impossible to inject any lubrication into 1,000 degree Fahrenheit steam.

It also had to be simple and reliable, and we found this valve system must work at high engine revolutions per minute. The high engine rpms does at least six things for us. By running our engine at 5,000 revolutions per minute, we are able to reduce our weight, our size, we are able to increase our efficiency, and we are able to increase the efficiency four ways:

One, we have less time the steam is actually in the cylinder for it to condense on the cylinder walls, there is less heat transfer down the cylinder walls into the crankcase, there is less thermal loss to the outside and less steam leakage past the piston rings.

For this reason we are using a high-speed engine. Our weight is half essentially of what could be done with, say, a 2,500 revolution per minute engine. The 5,000 revolution per minute engine is twice what has ever been done before, as far as I know.

The 2,000 pounds per square in pressure that we are operating at is twice the operating pressure that has ever been done before. All of this in an effort toward the most efficient engine possible.

We are doing several other things. We are using a transmission. We found it is more economical to go through a transmission to get the torque than it is by varying the cut-off in the engine.

In other words, what we are saying is if we would like to double or triple the amount of torque in the rear wheels, it is more efficient to go through a transmission which is 95 to 97 percent efficient than it is to try to get this increase in torque with the engine itself.

To do this with the engine is a sacrifice in efficiency.

We are also using a variable pressure boiler. We do a very minimal amount of throttle. Throttling is inefficient and it is to be avoided. Thus, we use a variable pressure boiler. We vary our horse-

power output by the amount of pressure that our boiler is putting out. We have very fast throttle response.

We have had several third-party people that have ridden in our car. We presently have a full condensing system installed in the backend of a Volkswagen. It has been running for over a year.

Mr. Lippmann, director of the California State Legislature, has been out and has been in our car. Dr. Richard Hill from the Dallas EPA, has driven in our car and will be glad to testify to its performance. 80 miles an hour is no problem. At 40 miles an hour we are getting 26 to 26½ miles per gallon. This is on the first prototype.

Granted, we feel like we have come a long way on our first prototype. It is a long way from being the refined IC engine that Detroit has. But what we believe is that we do indeed have an alternative to the IC engine, which is as efficient or more efficient, is lighter weight, and is cheap to manufacture.

We installed our system in the Volkswagen for two reasons, to demonstrate the small size and the light weight. We are getting about 70 horsepower out of our system at 5,000 revolutions per minute.

Senator TUNNEY. Let me just stop you there. There has been an awful lot of talk recently as a result of the decision of EPA to grant a 1-year waiver of the 1975 standards that it is impossible to meet those standards. I am just curious about your opinion of the decision that was made by the Environmental Protection Agency to extend by a year the 1975 standards.

On the basis of your research and development, on the basis of the prototype that you have built, do you have any real expert opinion regarding EPA's decision?

Mr. CARTER, Jr. Well, honestly, I feel they had no choice, because although there have been a lot of paper studies and components made, actually as far as to having a preproduction model car that will meet the 1976 emission standards that is ready to go into mass production, there is not one.

Senator TUNNEY. How long do you think it will take to get one, assuming adequate funds were made available for R & D contracts?

Mr. CARTER, Jr. These things don't happen just overnight. Detroit has had 50 to 60 years to work with their IC engine. I see in 2 years having 10 preproduction prototypes, gathering data, working out the reliability and the problems that are going to be there.

The one thing that Thermo Electron mentioned, and I am in full agreement with, is granted, we want as quickly as possible to have a nonpolluting engine, but at the same time we don't want to rush into something that we are going to have to live with for the next half century. I feel like there are a lot of smart people in this country, and there are a lot of good ideas out there, and what I would like to see is maybe some competition between these people to develop a system and then your best system is going to rise above, based on performance, merit, horsepower, emissions, and what not, and then from that we can direct even more and more money to those projects that do start rising ahead.

I should hope that the people that are in charge of funding the money would be technically qualified to judge on the merits and potential and performance of the system. I have heard a lot of paper

talk. I have heard a lot of "we can do this and that," and that's fine. That is where it starts. But actually what we want is a system that actually performs the best.

That is only going to come through development work and slowly weeding out and separating the better systems from the others.

Senator TUNNEY. We have a program by the EPA of approximately $7 million in research. Do you feel this is adequate?

Mr. CARTER, Jr. No, it is not. For one thing, it is too limited. Right now, it is basically three or four prime contractors. That is all the money they had to even study. Lear is only getting enough money that he can do just the very minimum amount of work.

I say there are several other companies and individuals across the country who have also demonstrated merit and potential who have no aid whatsoever. I would like to see competition with all of these.

Senator TUNNEY. How would you structure that competition?

Mr. CARTER, Jr. How would I structure it?

Senator TUNNEY. Let's say there were $35 million available; $1 million to 35 different manufacturers or developers of the technology would obviously be a waste of the money.

Mr. CARTER, Jr. Yes, it would.

Senator TUNNEY. You are an expert in this field and I certainly am not, and I would like to have your ideas for the hearing record on how you feel such competition should be strustured, assuming that the bills were passed and there would be money available.

Mr. CARTER, Jr. I think from reading your bill, and we were very happy to see your bill, it seems to us it would help people who appeared to be qualified, and to help them move ahead. But I feel like the success or failure of your bill is going to depend upon technically qualified people who can sit and judge different projects on their merit and their potential and decide whether they should have funds, grants, whatever, to continue in their work and review every 6 months or so their success and appropriate more funds then based on their past track record.

I say you don't want to give to 35 companies just because you have 35 companies. If there happens to be only five companies that this qualified individual feels are qualified, then there is just five companies that are getting the money, and then there is the competition. It doesn't take very long for a qualified person to start analyzing the results and see that one is starting to rise above the other, and then start directing more and more money and time into that one particular system that is moving ahead.

Senator TUNNEY. How much do you think your company would need to develop 10 preproduction models, say, in the next 2½–3 years?

Mr. CARTER, Jr. You understand we are a small company and actually we prefer to be that way, because we have the flexibility and we can actually move ahead much faster than a large company, which is obvious from what we have done in the last 5 years. We started from nothing, and I feel like we are as far ahead or further ahead than anyone else that I know of.

So, it doesn't take as much money for us as it might for someone else.

But to answer your question, we could have 10 preproduction prototypes going for $1 million. Now, that is small in comparison to what other people said. But we could do that.

Senator TUNNEY. In what period of time?

Mr. CARTER, Jr. In 2 years. The fact is we are already set up; we are already moving ahead. Whether we get Government funds or not, we are going to do it, and we have already established a program and a schedule for putting a second production or preprototype into a small automobile, and this to be done in less than 2 years.

Senator TUNNEY. Have you gone to EPA to try to get money?

Mr. CARTER, Jr. No; we never have. Actually, we never felt like we would get anywhere by asking them. As I said, we are a small company. My father has a terrific reputation in research and development. But it has been our philosophy to prove our system and show it and then ask for money. I felt like that probably we would have gotten nowhere, a small company down in Podunk, Tex. I am sure there are a lot of companies around, and there are a lot of individuals around that think they have the ultimate solution, and EPA is probably plagued with a hundred of them a day, that say "I have got the ultimate solution. I can get 25 miles to a gallon of water and I burn water". I suspect they get one of those very day. I didn't want to be classified that way. So, it has been rather to develope our system and now we are at the point where we feel like we have something that is competitive, and we are at the point now where we can really move ahead.

Senator TUNNEY. Do you need money from outside sources, or are you able to do it by yourself?

Mr. CARTER, Jr. We do have money available since we have our car running—actually we have more people than we need wanting to invest money in our system. Research and development is a funny thing. You just can't slap down $50 million and say there is the solution. It takes a process of evolution; a process of trial and error. Your whole system is going to have to work together. Somebody may have a boiler over here and somebody else may have an engine and somebody else may have a feed water pump. Unless all of this works together in a working system, you don't have something that is really competitive with the IC engine, something that you can go into production with.

So what we have worked on is the entire system. Now we are at a point where we feel pretty competitive; we have patent applications on our valve and almost every item of our engine. We are at a point where we could use some money to really move after this thing and get in high gear.

Senator TUNNEY. So, in other words, this legislation, if passed, could be of help to you?

Mr. CARTER, Jr. It could be of tremendous help to us. We are at the point now where we have a pretty well defined system. What we need to do now is to spend time nit-picking little bitty details of getting the ultimate system. This is the first prototype, and we are getting 26 miles to the gallon of gas. We haven't really spent a whole lot of time optimizing our engine design. We do feel like potentially we have the most efficient engine design that has ever been

tested. We are doing everything feasibly possible with our technology today to get just that.

Senator TUNNEY. Are you confident that you could get better than 26 miles per gallon if you had more experience with the technology?

Mr. CARTER, Jr. I hate to commit myself. I say that this was our first prototype. We got 26 miles per gallon. We have not even had the time to spend optimizing this system—optimizing all of the automatic controls and getting the thing to work like a unit. Once we had the thing working, we planned to go back and optimize.

Yes, I do, I believe we will. Certainly we will beat the IC engine in fuel economy.

Senator TUNNEY. Do you meet the 1976 standards?

Mr. CARTER, Jr. We have not tested our boiler. The fact is we considered bringing our car down here and then driving it back, but we were advised that we ought to have our emissions checked first. We have not really been too concerned about our emissions because there are at least a half dozen or a dozen other people who have demonstrated low emissions from boilers. Yet I have not seen anybody who has really demonstrated a complete working system. So, that is where our effort has been, toward that.

Yes, that is our next effort, is to get our emissions checked, and to get all our test results that we have done verified by a third party.

Senator TUNNEY. When will that be done?

Mr. CARTER, Jr. Just as soon as possible. We have been running our system on kerosene. We were advised or we feel like we will get better emissions on gasoline. So, we are in a process of changing from kerosene over to gasoline. Actually there was no major problem, but there was a slight problem for us, because gasoline boils at such a low temperature that at very low flow rates our gasoline was boiling, and was giving us uneven fuel distribution. That was not really a problem, but it was a problem for us to change over to gasoline, get our emissions checked and get here on as short a notice as we had. I believe we have pretty well solved the gasoline problem. We are running on gasoline now. It no longer boils.

Senator TUNNEY. Our next hearings are going to be on the 17th of the month, and then we will keep the record open for 30 days. So, if you do have an opportunity to have those emissions checked in that time period, I hope you will make them available to the committee, that data.

Mr. CARTER, Jr. Yes, we will be very glad to. I hate to commit myself on when we will have it. I have talked to several other people who have had their emissions checked and they tell me it is a little bit of a problem on a changeover, because most of your emission testing equipment is designed to test IC engines, which has 2-inch hoses that plug up into the exhaust pipe. This could pose some problems and we may have to do some work on that problem.

So, yes, we would like to, as soon as possible. That is our effort.

Senator TUNNEY. Have you sought any help from Detroit?

Mr. CARTER, Jr. No. Here again we felt the same way we felt with EPA. I feel like Detroit—personally I feel like they are waiting around for someone to come up with a system that will beat theirs. So far nobody has come up with anything but paper. There really

isn't a system that is competitive with the IC engine. When that time comes, when somebody does demonstrate that, then economics will dictate that Detroit will have to change, because if they don't, some foreign manufacturer is going to, and they are going to be able to produce a car that will meet the emission standards, will get better fuel economy, and the American people are just not going to stand for the IC version. They are going to start buying these foreign cars. Detroit from an economics standpoint will have to change over, and if they don't! I personally think that would be a good thing for the Detroit laborers to strike for, for Detroit to start working on a nonpolluting engine, otherwise they are liable to be out of a job or severely retarded in several years.

Senator TUNNEY. The thing that is amazing to me is that with the $10 of millions the major automotive manufacturers are spending on R. & D., they have devoted almost their entire effort—not totally, but almost their entire effort—to catalytic converters which will maintain the internal combustion engine.

Mr. CARTER, Jr. Yes, that is very disappointing, but actually it is human nature, resistance to change. They have been working with the IC engine for 60-some years, and there is a tremendous amount of inertia there to stay with what they have got.

It is a hard thing for them to do. I can imagine it is a hard thing for them to accept that their engine is no longer qualified for the situations of today. I think economics and foreign competition are going to dictate that they are going to change.

We brought a film which is about 7 minutes long, which shows our car running.

Senator TUNNEY. Yes, why don't you show it?

[While a movie was being shown, the following questioning took place:]

Senator TUNNEY. How long is the condenser up front?

Mr. CARTER, Jr. It is about 24 in. wide, 12 in. high, and about 2 in. thick.

Actually, the condenser in front is doing over one-half of our condensing. We just physically cannot get enough air through rear engine type condensers to condense all our steam. Our next installation will be in a front engine American car.

Senator TUNNEY. What about noise in comparison with the internal combustion engine?

Mr. CARTER, Jr. The noise is about like the Volkswagen engine that we replaced. We are sitting right in the engine compartment essentially. That deck shown there is in the passenger compartment and the noise is about like what an IC engine is. Most of our noise is our fan, because we have such a big condenser fan trying to get it through those louvers there on the side, whereas in a front engine car we wouldn't have to have quite as big a condenser fan.

Senator TUNNEY. Have any foreign car manufactureres shown any interest in your engine?

Mr. CARTER, Jr. No. I guess Mr. Lippmann was one of the first people we told about our system. We relatively stay pretty quiet. If somebody had asked me 2 years ago how long it would take us, I would have said we will have it in 6 months. It just doesn't work that way, and the people who say that in R. & D., I feel, are being

very optimistic. Things just do not go that way. It has been 2 years.

The car is probably capable of going over 90 an hour, but a Volkswagen inherently has a little oversteering tendency, and with our extra weight of 125 pounds located in the back, 80 miles an hour is really as fast as I care to drive it.

Senator TUNNEY. How many horsepower, would you say?

Mr. CARTER, Jr. Seventy horsepower, 5,000 revolutions per minute. Our system here is completely automatic. We turn the key; 20 seconds after we turn the key on after a cold start, the engine is running, 10 seconds later we can drive out and head off. We have several redundant features in it which prevent any damage occurring to the boiler due to high pressure or high temperature.

Senator TUNNEY. So is there a danger of explosion?

Mr. CARTER, Jr. No; none whatsoever. Actually at any one time we only have a quart of water in our boiler. We have had steam rupture and, it makes a loud noise. It may scare you, but it won't hurt you. It is inside the boiler jacket and there is no problem whatsoever.

Senator TUNNEY. How many miles do you have on that engine?

Mr. CARTER, Jr. We have over 2,000 miles. I wish I could say they were 2000 troublefree miles, but they haven't been. They have been development works, improvements, refinements. I can safely say now that we are in a position when I turn the key on, I can be reasonably sure it is going to start up and perform like I expect it to. We are down to that position now. The lubrication problem—we operate at a thousand degrees Fahrenheit plus 2,000 pound-force per square inch pressure, and that puts a tremendous load on our piston rings. Initially we did have excessive wear on our rings, because you can't inject oil into the steam. So we had to devise a system that we could lubricate our cylinder walls and our rings. We have solved the lubrication problem. We have run the engine—in fact we ran the engine with some molybdenum rings for about 50 hours at a thousand degrees Fahrenheit. We tore the engine down. The rings still had the machine marks in them from when they were manufactured. They had not even broken in. That will be a situation we will have to deal with, to break in our rings, because they just don't break in.

The two cylinders that you see here horizontally is a two-cyclinder reciproacting high-pressure-feed waterpump. The four cylinders that you see, it is a four-cylinder radial, 35 cubic inch displacement.

This total package, what you see there, our feed waterpump, our engine, our oilpump, throttle valve and all the insulation weighs 114 pounds.

Shown there is view which gives a better idea of the small size. This was the first prototype engine. It has been running for over 2 years, and it has been extremely reliable. It is probably the most reliable piece of equipment on our system. The only changes that we have made are the development of a lubrication system where we got real good ring wear and a valve seat in which we changed the angle so we insure a better sealing of our valve when it closed. The feed waterpump has also run for over 2 years. No problems, other than experimenting with different types of packaging.

[End of film.]

Mr. CARTER, Jr. Essentially we have had our engine, our feed waterpump, running for 2 years. The area we have been spending time on for the last 2 years is actually developing all the automatic controls and simplifying them and making them reliable and redundant enough that they will last in a car for 100,000 or 200,000 miles. That engine will easily last, and I am not being optimistic to say it will last 200,000 miles. The boiler, they have powerplants that run day and night for 10 straight years, and our boiler essentially is no different than a boiler in a big powerplant. So, actually the problem is working out all the automatic controls, and we are much simpler today than we were a year ago. That is difficult.

You may not believe it, but to get something simple and reliable is much more difficult.

Senator TUNNEY. I believe it.

Mr. CARTER, Jr. It takes a while. Our first approach was a pretty complicated idea. It has gotten down to where it is pretty simple, it is reliable, and I fully believe that our next prototype will beat the socks off the internal combustion engine.

Senator TUNNEY. When the National Academy of Sciences was preparing their report to the Congress which was published on February 15, did any representatives of the National Academy of Sciences come to your plant and observe what you were doing?

Mr. CARTER, Jr. No. As I said, we have been pretty quiet. I would rather do it and then show it, than I would to say I am going to do it and then not be able to make it in the time I said I was going to make it. I just heard a lot of paper talk and I heard lots of people say they were going to do something, and I just don't want to be classified that way. I would rather do and then say.

I did give a talk at the EPA meeting in Ann Arbor in December, and George Thur came down just about 3 weeks ago, I guess, and we met him at the airport, drove out on the expressway, and I think he was very impressed with the throttle response and how fast it started up. When it has been shut down for only 2 hours, it starts in 10 seconds and we are ready to drive off.

Senator TUNNEY. It is very, very impressive, Mr. Carter.

One last question: Do you anticipate any problems in developing your engine to power up larger cars?

Mr. CARTER, Jr. No; actually it would be much easier on a larger car than it was on that small size. We had to be pretty nit-picky about how we built things and how it was all designed to fit into that small package. Larger engines would be easier, much easier.

Senator TUNNEY. Mr. Dutcher, who testified just before you did, indicated that he thought that the difficulty came with the larger type automobile, that it wasn't as much of a problem with the smaller type.

Mr. CARTER, Jr. I think maybe he was referring to emissions. When you go to a larger automobile, of course, you have to have a larger boiler, and for the same percentage emissions, you are going to put out more emissions per mile. So, to get a larger boiler to put out the same emissions per mile as a smaller one, yes, it would be more difficult.

Senator TUNNEY. This has been fascinating testimony that you have given, and I appreciate it very much. It has been a very, very valuable contribution.

Mr. CARTER, JR. I would like to say one thing. We appreicate the opportunity to come to speak and give our viewpoints on the bill and present what we have done so far. I would like to say that I am very happy to see your bill. I think it has probably more, far-reaching effects on this country than anything done in the last, I don't know how many years. I think, though, the success or failure of this bill is going to be dependent not so much maybe on the bill, but the people that you appoint to see that it is carried out. I think the people that are appointed to see that it is carried out need to be qualified people that are technically oriented, that can decipher between something that is paper talk and wind and decipher between something that has potential and has merit and award contracts and verything on that basis.

It is possible that you can spend a tremendous amount of money going down a blind alley, and if you have got somebody that is technically oriented and can see ahead to the blind alley and stop that project and go and work with projects that have merit, I think it is great. I hate the idea of three foreign manufacturers being able to meet the 1975, standards and the United States is saying that it can't be done or at least some factions of the United States are saying it can't be done. I believe from the testimony given today it is obvious that we can do it. It is just a matter of putting the money in there and let's go, get behind it.

Senator TUNNEY. It is terribly impressive to me that you and your father and the others that are associated with you really on a bootstrap have been able to accomplish what the multibillion dollar corporations say is impossible to accomplish, which I suppose is the American way.

Mr. CARTER, JR. I like to think it is the American way. We have been lucky. We have had a lot of heartbreaks, a lot of things break, and I guess I have my father to thank for the success of this thing. He has been a consultant, because he has a full-time research and development of his own. When I have my father, I have somebody that I can go to and talk with. I have people who are completely committed to see this thing go. We do—I am not saying we will, but we have been working from 7 o'clock to 6 o'clock every day. I am getting 95 percent efficiency out of them. It is amazing how much work they get done in a day.

Senator TUNNEY. Thank you, it is really great. It is a very, very important statement that you have made. As acting chairman of this committee, I deeply appreciate it.

[The following information was subsequently received for the record:]

THE CARTER STEAM SYSTEM

Our Rankine cycle system approach for an automobile is new and different from that used by other developers. The engine is a four cylinder radial, single acting uniflow without crossheads, and is designed to operate on 2000 psi steam at 1000°F. Cut-off and clearance volume is fixed at a combined efficient 8%. Power modulation is accomplished by varying the boiler pressure and by the use of the standard four speed gearbox of the Volkswagon. Bore and stroke are 2 and 2¾ inch respectively, and the engine develops 70 h.p. at 5000 RPM. The engine is not reversible, the gears being used for this function. Water and oil pumps are driven off the engine as is the alternator and the engine is idled for warm-up and to handle the accessory load. In addition, a blow-down feature is provided to shorten warm-up, which takes place in 20 seconds. Drive-away time is 30 seconds from turning the key on a cold start. The steam system is completely automatic and operates the same as the present automobile. There are redundant features built into the control system which prevents damage occurring to any of the parts.

Splash lubrication in the crankcase along with an oil injector which feeds oil directly into the piston rings and cylinder has been successful. A special high temperature oil made by Mobil Oil Company is used as are channel chrome cylinder walls and molybdenum rings. Bearings are pressure fed. Crankcase temperature of 250°F boils off the little condensed blowby that occurs.

The boiler is 13″ in diameter x 26″ long, a monotube type using finned tubing. A modified spinning cut fuel atomizer feeds the modulated fire. Steam temperature is controlled to plus or minus 50°F with a peak thermal output of 1,250,000 BTU per hour.

At 70 mph, fuel consumption is presently 17 miles per gallon. At 40 mph, fuel consumption is 26 miles per gallon. Kerosene is the fuel used although EPA has suggested a low grade of gasoline. Our condenser employs a vacuum in the best power house tradition. On a 100° day the condenser will maintain a pressure of —2 inches of mercury to 2 psig at 70 mph and —15 inches at 40 miles per hour.

Weight of engine, feedwater pump, throttle valve, oil pump and filtering system is 114 lbs. Weight of the boiler, blower, atomizer, and automatic controls is 125 lbs. The total system weighs 120 lbs. more than the original I.C. system, but includes the condenser weight which is made out of brass and lead.

COMMENTS ON S. 1055

(By J. W. Carter)

Jay Carter Enterprises, Inc.

The Bill S. 1055 is good in that it provides funds for the development of a low emission alternative to the internal combustion engine. The only question we have to the bill itself, concerns paragraph (4B) Section 2. Could it not be possible to develop a power system that is clean and competitive with the internal combustion engine and yet not fit in an existing motor vehicle with out major changes?

The bill is in agreement with the American tradition of free enterprise; incentive for the individual and small company with contracts and compensations given on the basis of merit and accomplishment.

The success or failure of this bill will depend not on the bill but upon the persons assigned to carry it out. We feel it is very important that these persons be qualified to judge different projects on potential and merit and award Federal grants and contracts on this basis. Much money has already been spent by individuals, companies, states, and governments to develop a low-emission vehicle engine. Unfortunately, some of this money was spent in the wrong direction. Needless to say, in order to get the best results from the tax payers dollar, the money must be spent wisely and this can only be done by qualified people.

Senator TUNNEY. Our final witness for today is Mr. Leonard J. Keller, president of the Keller Corp., Sarasota, Fla. Welcome to the committee, Mr. Keller. I don't know what your pleasure is, but if you desire to summarize your statement, your statement will be included in the record as if read.

STATEMENT OF LEONARD J. KELLER, PRESIDENT, THE KELLER CORP., SARASOTA, FLA.

Mr. KELLER. I think I would rather not summarize the paper but to proceed as you have been doing. It seems to be quite effective.

That would suit me very well.