Mr. DADDARIO. Could you yield just one matter there?

Mr. CONABLE. Yes.

Mr. DADDARIO. I think Mr. Conable raises a good point. It can't be done overnight by any means. We have talked here in the last few days about Lake Erie and somebody has put a price tag of $10 billion on cleaning it up. How do you think we ought to go about it if we apply your philosophy? Should we spend the $10 billion?

Mr. RAYNES. I think we ought to go about it the way the housewife goes about cleaning her house. She wants her house cleaned up. She doesn't use surveys and she doesn't need standards. She knows what she means by a clean house and she goes ahead and gets it clean. She may know that there is going to be an improved detergent to help her clean her dishes coming along in 6 months. In fact, it may even be being market tested in her sister's home 150 miles away, but in the interim she has got to get her dishes clean. I think that the answer may be almost as simple as, let's start cleaning up everything that goes into Lake Erie and then the lake will get clean. That's what I think.

Mr. DADDARIO. Do as much as you can to prevent additional pollutants from contaminating further.

Mr. RAYNES. And then when that promising new process comes along put it to use.

Mr. DADDARIO. Taking into consideration what you can afford to do during this period of time.

Mr. RAYNES. The housewife may not be able to afford that dishwasher right away. In the meantime she still has to have clean dishes.

Mr. DADDARIO. Perhaps with the expenditure of x number of dollars, you could get Lake Erie to the point where the trend of this growth which is causing so much concern is at least reversed. Have you applied standards in that sense? The approach to improve conditions back to a certain point?

Mr. RAYNES. I think that could work. My feeling is, I am obviously a conservationist as well as a scientist—that the people want to see their waters clean. You could perhaps adopt a standard that when the conservationists have stopped screaming about it, then it is clean enough. That might not be too acceptable a standard in certain places. But this is what happened in this country 60 years ago. All the rivers and basin harbors—I'm quoting a Presidential report—they began to stink so people began to complain and the present procedures for cleaning up sewage wastes were put into practice. That was in the early 1900's. Well, now they are beginning to stink again. So I think we ought to clean them up to at least the point where they don't do that.

Mr. DADDARIO. I think you could establish a standard by saying that streams are clean when people stop screaming, but I wonder if we couldn't reach the point where things get so bad people stop screaming and take it for granted. Take your housewife. She might take a look at the dishes piled up and just walk out the front door and leave them there.

Mr. CONABLE. The only other question I have relates to this trouble-shooting group which is such a good idea that I wonder if we are not already doing it.

Mr. RAYNES. Well, in talking to these operators, they have told me that they can write to Cincinnati, where the Robert A. Taft Sanitary

Center is or to their State. That is about the best they can do if they don't have a travel budget. But they don't often have a chance to have someone come to their plant and spend a few days and say, Oh, yes, what you should be doing is this and this, and try that and that. I do not know of the existence of such a group.

Mr. CONABLE. This strikes a responsive chord with me because we had some hearings of the Subcommittee on Natural Resources and Power of the Committee on Government Operations up in Rochester this past week at which I was present because I happen to represent part of that area. The Eastman Kodak Co. was on the panel as well as others. Eastman has had primary treatment of its industrial waste for some time but they have not gone to secondary treatment. They have plans for it and have been doing a lot of experimenting on it. We discovered that they had requested health services from State and Federal sources to help with some specific chemical problems they have. They were told to go ahead and experiment and to figure it out alone because they had a unique problem. This put them in the position of relying on their own research department again. I imagine this example is fairly typical in industry particularly because each industry has really a different type of problem, many of which admittedly have techniques that can be addressed to them and many others of which probably don't.

Mr. RAYNES. Yes; some still need work.

Mr. CONABLE. Yesterday, in talking with the water pollution people we were advised that the best techniques available now, primary and secondary treatment and the activated carbon treatment beyond that, would not have any effect on dissolved chemicals.

Mr. RAYNES. Inorganic chemicals.

Mr. CONABLE. Inorganic chemicals, that is right. We apparently do still have some substantial technology problems. It is not just as simple as saying, "Let's clean it all up tomorrow."

Mr. RAYNES. If there weren't some additional problems I wouldn't be around talking large-scale development programs.

Mr. CONABLE. But you are not aware of any really substantial troubleshooting group in the country.

Mr. RAYNES. In my experience, which is limited to about 3 years, I haven't found such a group. There are water pollution agencies, scientific organizations that provide handbooks and this sort of thing, and these are personal contacts, but I don't know of any Federal group which is able to go out and help these fellows on the spot.

Mr. CONABLE. I'm very much inclined to agree, Mr. Chairman, with Mr. Raynes' testimony that this is going to require the force of law to clear it up and it is also going to require the Federal Government in a large measure.

Mr. DADDARIO. Mr. Raynes, I would look to ask just one question before I turn the questioning over to Mr. Brown.

I'm reminded that you touched upon the fact that industry is interested in pollution abatement devices because they see a market possibility. Do you have any estimate as to the size of this market? What kind of incentive should we consider as we review this problem?

Mr. RAYNES. The figure of $10 or $20 billion just for the Lake Erie watershed is one I've heard. I think it came from an HEW survey,

made by the Public Health Service as I recall. It is just one indication of a rather large business. That's, let's say, $10 billion to be expended in one part of the country hopefully in 10 years. That's a very large business and when you extend that to the entire country, I have heard figures as high as, I think, $40 billion, something of that sort.

I think American industry picks up its ears when it hears $40 billion in 10 years.

Does that answer your question, sir? My understanding is that that is water pollution abatement work alone, and does not take into account air pollution control and all the other environmental pollution problems.

There is something like a $2 billion chemical and equipment market per year right now just for existing sewage treatment facilities, not taking into account new facilities that are going to be put in.

Mr. DADDARIO. I ask the question not because there is any precise answer that can be given to it, but because as we go through these hearings, it becomes clear that if we undertake to do the job we need to do there is every reason for industry to use its best efforts to participate.

Mr. RAYNES. Yes, sir.

Mr. DADDARIO. There will be some economic advantages to them.

Mr. RAYNES. Yes, sir.

Mr. VIVIAN. Will the chairman yield?

Mr. DADDARIO. Yes.

Mr. VIVIAN. On that particular point we just discussed, the information which I received from one of the agencies fairly recently indicated that over the next 20 years approximately—I think we picked 20 years simply as an arbitrary time to allow sufficient investment to take place and existing plants to wear out—on the order of $30 to $40 billion will be spent for operation and installation by municipalities and such organizations if they followed the present trends and bought present equipment.

Mr. RAYNES. In just water?

Mr. VIVIAN. Just in water—this represents approximately a billion and a half a year. This will, however, by no means meet the demand. This will leave us with worse conditions than we now have. According to the estimates made, if we tried to clean up all river systems to the secondary level and only a very limited number to a tertiary level, the cost would run to about 2½ times that amount, or $100 billion nationwide, of which roughly $20 billion would be in the Great Lakes, and roughly $5 billion in Lake Erie. An increment of about $40 to $60 billion is necessary to make a dent on the real problem rather than simply staying behind as we are now. I think that's approximately the size of the market.

Mr. DADDARIO. Does that make sense to you?

Mr. RAYNES. Yes, sir. It is a big market.

Mr. DADDARIO. You agree it is a big market.

Mr. RAYNES. Yes, sir.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. I wanted to get some views from you on another aspect of the problem. We are holding these hearings primarily, of course,

to determine the Federal role and you have made suggestions here. For example, you suggested that this troubleshooting group be available through the Federal Water Pollution Control Administration.

On the other hand, you have also suggested the use of zoning as an instrument in the field of pollution control. This is a highly local operation generally, and I raise the question with you as to the emphasis which should be placed on local or regional versus Federal activity in this field.

If I may just indicate a point of view, being from Los Angeles, I have some experience with the problem of pollution control in Los Angeles.

We have, for example, an air pollution control district which covers the entire county. We have county sanitation districts which are combined under unified administration operation to operate the trunk sewage system, although there are local sewage systems also.

We have a regional planning organization which controls the zoning in unincorporated areas, and there are local planning bodies within each of the 75 or 80 incorporated cities.

Now, the air pollution control districts can take some steps and have, for example, prohibited backyard incinerators to control smog. What this did, of course, is force more grinding of garbage which puts more load on the county sanitation districts. Or else it created greater loads of solid waste which in most cases are collected by private firms.

The county regional zoning operation, by virtue of its power to control the location of industry, can determine the burden of pollution in given areas and can also determine how pollution can be corrected by setting standards.

I'm suggesting to you the complexity of the local problem. Might not one major effort be in the direction of putting more responsibility on local and regional organizations and at the same time compelling a more rational organization at this level? What is your reaction to this?

Mr. RAYNES. I think the Federal Water Pollution Control Administration, I always speak about that because I know more about water pollution than other forms, is talking about watershed management now rather than localized management. In watersheds the entire drainage system of a stream or lake is considered, and the cooperation of all the individual political entities is required.

If they don't cooperate, of course, the thing doesn't work well. Your Los Angeles area, I think, is one of the ones that is always pointed out to as an example of how things should be done. It is almost unique in the country, is it not?

Mr. BROWN. Well, to a certain extent, I think it is, but if it represents the acme which has been reached in this country, we are in real serious trouble.

The Federal Government has begun to exercise leverage in terms of planning grants and this sort of thing to compel a rationalization of the governmental process at the local level.

The point I'm raising here is, Don't we need to accelerate this a great deal more? Don't we need to use the Federal lever to compel a great deal more coordination in the various types of pollution abate-

ment efforts if we are to achieve any results? As in Los Angeles, for example, action in air pollution is frequently taken without consulting the sanitation control districts, without consulting the regional planning agencies, and almost always results in putting additional burdens on these other bodies as well as on local government and on private citizens. This is not the proper way to get results or to solve the problem in this area.

Mr. DADDARIO. That comes under the heading of better management that you touched on.

Mr. RAYNES. Yes, I think it would be preferable if they could do it locally. But, if the local agencies won't do it, yet the people want it done, I think there is only one way it can be done.

Mr. BROWN. The Federal way.

Mr. RAYNES. Some Federal way.

Mr. BROWN. I wish I could agree with you on that, but I almost am forced to the conclusion that if the problem is not being solved and can't be solved locally in a metropolitan region with 10 million people in it, a population which is greater than a large number of countries in the world, that all the Federal Government can do by direct action is probably to make the problem worse.

Now, maybe I'm pessimistic about this, but it seems to me that the step for the Federal Government to take and the role that it should exercise is that of compelling the local organization to rationalize itself so that it can solve the problem there. In Los Angeles we shouldn't have to send to Washington for experts. We have the experts in Los Angeles. Nevertheless we frequently end up going to Washington for them just because we aren't organized to take advantage of what we have in Los Angeles.

Mr. RAYNES. That's the management end. You are now talking about a political problem which is outside of my sphere and in yours.

Mr. BROWN. Thank you.

Mr. DADDARIO. Mr. Brown does put the problem in the proper perspective.

Mr. RAYNES. He certainly does.

Mr. DADDARIO. You are talking about a group of 10 million people with a problem that affects them personally. They certainly ought to be more concerned about it than the Federal Government. It is hard to argue with your logic, Mr. Brown.

Mr. Vivian?

Mr. VIVIAN. Mr. Raynes, I have about six points to cover here.

I'll start off by saying that I hope that the Federal role in controlling ollution can be a strong and effective one. I have voted that way, but would not suggest that one be too hopeful. For example, we depend pon the voter for authority and that same voter doesn't wish to have osts imposed upon him by local property taxes and other taxes. It s a question of when he should take out his anger and on what level. I think this is classically illustrated in the bill before us in Congress his week. We have a bill before us to establish civil rights in certain reas, one of which is housing. When the bill was first written, it was ore rigid than the existing legislation in my own municipality.

At the first amendment, it became less rigid, and less effective than he bill of my own municipality. I will predict that before it is passed

it will be virtually innocuous so that the Federal role is not necessarily any stronger than the local role, depending upon the motivation of the voters in the area concerned. You have to motivate the voters to want results rather than simply rely upon the Federal legislators to tell the voter.

To go beyond that, I would like to ask about the effective operating life of typical secondary treatment plants.

Can you tell me what the wear-out time is for typical secondary treatment plants?

Mr. CONABLE. Is there such a thing as a typical secondary treatment plant?

Mr. RAYNES. There are conventional ones. I think they are generally amortized between 20 and 40 years, depending upon what the general municipality action is. I think 40 tends to be the average. There is a survey on that, on sewage treatment plant costs that I don't have with me. It was put out by the Public Health Service last year, about 9 months ago. The title of this publication is "Modern Sewage Treatment Plants; How Much Do They Cost?" Public Health Service publication No. 1229 (1964).

Mr. VIVIAN. I'm interested in any information which is available on this subject for insertion in the record, Mr. Chairman, because I think it is going to show that research which might be started now or be partly along now which will lead to pilot plant work in the next few years and eventually to installation of plants in various cities, will come along at a time when it can replace a very large fraction of all operating treatment plants today.

In other words, we shouldn't assume that just because a city has a treatment plant now that that plant will not be replaced within the generation or perhaps even a decade.

There are often times when it is cheaper to replace large portions of a plant than to continue utilizing an out-of-date plant, and this trade-off curve can be very shallow at times.

Over a period of years it may be very difficult to see what the right year to drop an old plant may be, but usually there is merit to it, and of course, plants are also technologically displaced.

If you come up with a cheaper plant, many cities say find a cheaper way and keep it because it will be in the long run cheaper. I would like to see more information on that subject if it is available. It can pace the R. & D. system to some extent.

The next item is the subject of the powder coal treatment process in which your firm is involved. I understand that to date you have run tests on fairly large samples of a variety of effluents and are fairly convinced that the process works. I would like to know what you now know about the cost of this process as you project its application versus the cost of other treatment processes.

Are you in a position to make any statement on that subject?

Mr. RAYNES. I can say that we are convinced the process works. The applicability of coal in treating liquid wastes is established. It is a question of economics that remains, the economics and how good the effluent is. We are building a pilot plant in which the economic estimates we have made will either be proved or disapproved. Our present prediction is that coal can treat sewage and remove more

contaminants than are presently being removed in conventional secondary processes at something about 10 percent less cost than the present processes, even if one does not recover the thermal energy still retained by the coal. Even on that basis.

If one has a large enough plant or some place to recover that thermal energy, then the cost should go down quite substantially over that 10 percent reduction.

Mr. VIVIAN. Can you tell me whether or not you have reached the point where any large-scale installation is being contemplated? I recognize that your reply might get into difficulty with corporate information.

Mr. RAYNES. Our pilot plant will be a quarter of a million gallons a day, and that's the biggest operation we have got going now. Many people are talking to us about what is going to happen with the process assuming that it is successful. We would like to see the coal-based process, and any new process that looks like it is going to help the pollution problem, get going as soon as possible.

Mr. VIVIAN. I understand it is a proprietary process covered by patents, is that correct?

Mr. RAYNES. No; the process belongs to the people.

Mr. VIVIAN. Therefore, whether the process is applied or not is principally a question of whether some firm will begin to make quotations and bids on specific plants and back them up with some form of guarantee?

Mr. RAYNES. Yes, sir.

Mr. VIVIAN. Can you compare the powdered-coal process to the carbon-absorption process which I presume is the principal established process today?

Mr. RAYNES. The carbon process is also in a pilot plant as I understand it, except perhaps in one installation at Lake Tahoe. The powdered-coal process that we are developing is a process intended to provide sewage treatment superior to present secondary treatment processes, whereas the carbon-absorption process is a tertiary treatment following conventional secondary treatment.

When we get a chance we will look at tertiary treatment using coal. We may be able to cut costs in tertiary treatment too, but right now there is no real competition between the processes. One is tertiary, the other, secondary treatment.

Mr. VIVIAN. I understand the carbon-absorption process uses finely pulverized pure carbon, is that right?

Mr. RAYNES. Not too fine. The last technical paper I heard on this subject specified granules.

Mr. VIVIAN. And, the coal process uses different material?

Mr. RAYNES. Yes. Like table salt in size.

Mr. VIVIAN. What difference is there between these materials?

Mr. RAYNES. Activated carbon is frequently produced by charring coal, and in the process takes away from the coal some of its volatile ingredients. The coal is as mined except for sizing.

Mr. VIVIAN. The binder type of ingredients.

In other words, the two processes are very similar except the extra stage of charring is used to get increased activity.

Mr. RAYNES. There are similarities in the two processes. However, the activated carbon is regenerated by thermal-heating of a portion

of it to reactivate it, and the carbon is recycled with some loss. In the coal process the idea is to use thermal energy because coal is sufficiently cheaper to make energy recovery economically attractive, and it also provides a disposal for the sewage solids and dissolved materials which have been removed. There are some other differences too.

Mr. VIVIAN. Does the carbon-absorption process work on thinner effluents?

Mr. RAYNES. It depends on what basis one uses. A pound of charcoal can take out more impurities than a pound of coal can, but if you have no limit——

Mr. VIVIAN. Let me restate my question.

Suppose you use the secondary plant which is a biological plant in part with a carbon-absorption process, will you then provide some fuel to reprocess the carbon?

Mr. RAYNES. Yes, if you use carbon. You have to put energy in to regeneration of the charcoal.

Mr. VIVIAN. If you use a coal treatment plant and take the heat from the coal to regenerate the charcoal, you could have a combination of a secondary and tertiary plant with self-generated heat, is that correct?

Mr. RAYNES. That is possible; at least part of the energy requirement.

Mr. VIVIAN. Is there any merit to using coal and charcoal in the secondary stage?

Mr. RAYNES. There very well may be. That's a good idea. And I think also merit in considering using coal in combination with some of the other processes Dr. Weinberger described yesterday, such as electro-osmosis and the like.

Mr. VIVIAN. Are plants being developed which include multiple stages?

Mr. RAYNES. No. I don't know that an actual pilot plant would be necessary. I think one could couple the information from each.

Mr. VIVIAN. On this whole subject of pilot plants which you mention on page 4 of your statement, I think the problem has been, and I think you probably will agree, that typical municipal systems have no margin for experimentation.

Mr. RAYNES. That is correct.

Mr. VIVIAN. Most communities are extremely reluctant to buy a plant which has any residual doubt about its operation. They would rather have a 90-percent plant that they are sure of than a 95-percent plant that might go wrong.

Mr. RAYNES. Yes.

Mr. VIVIAN. Is the Federal Government the only agency which is doing pilot plant research in volume? How much work is being done by private, State, and municipal agencies to develop better plants?

Mr. RAYNES. You said the only agency in volume? I think that is correct. I think it is the only agency in volume. There are State programs but they are not generally pilot programs. I can't, sitting here, recall of any.

Mr. VIVIAN. Going down further, do you know of any municipal plants that are doing research and development on treatment plants?

Mr. CONABLE. Chicago is, isn't it?

Mr. RAYNES. Yes; I think Chicago has or is contemplating one or more, yes. I think there may be a few. Los Angeles?

Mr. VIVIAN. The volume is not impressive.

Mr. CONABLE. Will the gentleman yield for a minute? I asked the commissioner of public health for New York State last week how much was being spent on research in New York State. They have a billion dollar clean water program there that they are very proud of, for which the people voted a billion dollar bond issue. He said, that he didn't know, but maybe a couple hundred thousand was being spent on research—a very minimal State research program.

Mr. DADDARIO. One of the problems probably is that, although you can finance the construction of a plant through bonding, you cannot finance research and development work in that way and you must use direct appropriation. It gets back to your original statement on the problems of obtaining tax dollars for these purposes.

Mr. RAYNES. Ther are sewage treatment plants for example, which have grants to survey the phosphate situation now.

Mr. VIVIAN. Grants from whom?

Mr. RAYNES. Usually from the Federal Government. But that's not pilot plant work.

Mr. VIVIAN. In the past, State governments have financed large amounts of research in agriculture for their own State areas through various universities in the States. Is there any evidence that this is a significant factor in the research? I gather from Mr. Conable's comments that this is not the case in New York, one of the biggest States.

Mr. RAYNES. Some 20 or 30 years ago Kansas used to do a lot of this, but I don't know about now. California does some. It is not a very large factor in the situation.

Mr. VIVIAN. For a market estimated in the tens of billions of dollars, how much do you find being invested in research by private industry?

Mr. RAYNES. I'm not able to answer that because I don't have enough data, but I do know that we are getting increasingly more contact. I know that some companies are starting to look at water pollution and air pollution abatement more than just casually, more than just saying: "Oh, there's a market, let's think about diversifying into it." There are more people looking into it than there were 5 or 10 years ago, and with deeper comprehension.

Mr. VIVIAN. I know that one firm in my own district is considering setting up a pilot plant in conjunction with your own company. This is evidence of the interest of private industry. I think we should stimulate this interest because it is necessary before hardware can be bid upon and quoted to municipalities.

I think it would be well to have the Federal Government act in such a way that it leads private firms to set up their own pilot operations.

You refer on page 5 of your statement to the zoning problem and I agree this is a very serious question because zoning boards, particularly the waiver boards, are usually given authority to scrap any laws for the purposes of a single installation or industry.

Mr. RAYNES. Yes.

Mr. VIVIAN. You also point out that people are allowed to build on flood plains, and other areas that everybody knows in advance are the wrong places to build. I don't imagine you have any answer

to this question, but do you see any difference between regional organizations, such as exist in Dade County in Florida, and other areas such as Detroit whose environs are chopped up into many small municipalities? Do you see any difference between the approaches being followed?

Mr. RAYNES. I'm sorry, I don't know enough about that situation. I would like to read about it, but never have.

Mr. VIVIAN. I think that's as much as I want to cover at the present time, Mr. Chairman.

Mr. DADDARIO. Mr. Ryan?

Mr. RYAN. I simply would like to commend you, Mr. Raynes, for your statement. I think it is an unusually fine presentation of the philosophy which we should be following in this area, particularly your point that we should not permit the lack of technology to prevent us from using what we have. I simply wonder if you have any specific suggestions for legislation which might be enacted at the Federal level which would force industry to use present technologies and present techniques to clear up environmental pollution. For instance, would you recommend industrywide standards? Have you any other thoughs as to specifics that we can deal with?

Mr. RAYNES. I really don't know very much about your field, sir, political science.

Mr. RYAN. I'm really asking what the Federal Government could do in the way of legislation. What could it say to industry that would require industry to make full use of present technology in order to clear up waters and the air?

Mr. RAYNES. Oh, well, speaking again personally, for a long time industry has, in general, said: "If you make us clean up here in the city X, we will take everything and move it to city Y, and you will lose your tax base and people will be thrown out of work.

Mr. RYAN. Isn't that a good argument for countrywide national standards?

Mr. RAYNES. Yes. If polluters couldn't go to city Y, if standards were the same all over the country, I think you could take care of that particular excuse to keep on polluting. I would like to see, in other words, the force of that argument taken away from industry wherever they are still using it. Many industries are no longer using that ploy, by the way. They are starting to put in pollution control measures that are required. But there are still some who resist.

Mr. DADDARIO. To properly answer Mr. Ryan's question, you would have to take a survey of what in fact is being done in industry and not assume that in every instance nothing is being done.

Mr. RAYNES. That's right. Plant surveys, not stream surveys.

Mr. DADDARIO. Then, using the results of this survey, we would have to decide if Federal intervention is necessary.

Mr. RAYNES. I recognized when I use the word "industry," that I am being unfair to many individual corporations that are cleaning up after themselves. But, on the other hand, usually when the polluters attack the conservationists, they show little mercy, so I don't feel too badly.

Mr. RYAN. You say in your statement, production management will dump and vent just so long as it can get away with doing so. The

question really is: What can we do at this level to set standards which would apply industrywide and compel industry to measure up to those standards? If they are doing more, fine. If they are already doing it, then they wouldn't be affected.

Mr. RAYNES. I think that is the enforcement part of the problem. Federal enforcement very likely.

Mr. RYAN. I know we have another witness. I think this is an interesting area to pursue, Mr. Chairman.

Mr. DADDARIO. I don't know if you were here, Mr. Ryan, when Mr. Vanik testified the first day.

Mr. RYAN. Yes.

Mr. DADDARIO. This was a proposition which he put forth, and certainly one which the committee has before it, and will consider. As I understand Mr. Raynes' position, he knows this job has got to be done, but we shouldn't forget the work being done by certain industries. There is a least common denominator problem. I know in Connecticut they are doing a great deal of work in this field, but others are continuing to pollute so that the work, in fact, is not effective.

Thank you very much, Mr. Raynes. We certainly appreciate your help, and I hope we might still have the opportunity to send some questions to you and discuss some of these points with you further.

Mr. RAYNES. I will be very happy to do whatever I can.

(Additional questions and answers for the record will be found in volume II.)

Mr. DADDARIO. Thank you ever so much.

Our next witness is Mr. David C. Knowlton. Would you please come forward, Mr. Knowlton.

Mr. Knowlton is the president of Knowlton Bros., Inc.; chairman of the board of governors of the National Council for Stream Improvement, and on the board of directors of the American Paper Institute. I'm pleased to see, too, that he is an industry member of the New York State Water Resources Commission and will probably be able, therefore, to answer a couple of other questions which I noticed were causing some interest earlier.

Mr. Knowlton, would you proceed, please? Would you identify for the record, your colleague, please?

STATEMENT OF DAVID C. KNOWLTON, PRESIDENT, KNOWLTON BROS.; ACCOMPANIED BY DR. HARRY W. GEHM, TECHNICAL DIRECTOR

Mr. KNOWLTON. Thank you, Mr. Chairman and members of the committee. I have accompanying me, on my left, Dr. Harry W. Gehm, who is technical director of the National Council for Stream Improvement.

I ask Dr. Gehm to accompany me because it may be desirable to have him participate in answering some technical questions that would be beyond my ability.

Before getting into my statement, I would like to say Mr. Daddario, that we are very much impressed with this publication (Note: Witness referred to Report of the Research Management Advisory Panel through the Subcommittee on Science, Research, and Development

to the Committee on Science and Astronautics, committee print entitled, "The Adequacy of Technology for Pollution Abatement") and the approach expressed therein. It raises what are to us some very searching questions that need to be answered, and we think this is the right approach to this broad problem.

The pulp and paper industry, through the National Council for Stream Improvement, as well as the Sulphite Pulp Manufacturers' Research League and the Northwest Pulp & Paper Association, carries on intensive investigations in the fields of stream ecology, effluent treatment, and waste utilization. (Information provided on this subject may be found in the committee files.) Also, the Institute of Paper Chemistry conducts biological surveys and undertakes special projects for individual companies in fields related to stream improvement. The largest and broadest effort is that of the National Council for Stream Improvement, since the Sulphite Manufacturers' Research League deals mainly with byproduct recovery from spent sulfite liquor and the Northwest Pulp & Paper Association with surface water problems common to the Northwestern States. Both these latter organizations cooperate in the national council's activities participating from time to time in projects of mutual interest.

Mr. VIVIAN. Mr. Chairman, I have an informational question.

I presume the council is supported totally by the pulp and paper industry. Is that correct?

Mr. KNOWLTON. Yes, sir; it is. It is a nonprofit organization supported by about 85 to 90 percent of the establishments within the industry. Its objectives are twofold. Research and engineering, and technical assistance.

Mr. VIVIAN. Are contributions to the council considered tax deductible?

Mr. KNOWLTON. Yes, sir; it is an operating expense.

Mr. VIVIAN. Thank you.

Mr. KNOWLTON. The national council maintains five regional research centers which are as follows:

In New England, the New York region at Tufts University in Medford, Mass.

In the South Central, Middle Atlantic region, the Johns Hopkins University at Baltimore, Md.

The Southern region, Louisiana State University in Baton Rouge, La.

The Central and Lake States region, at Western Michigan University in Kalamazoo, Mich., and

The West Coast region, Oregon State University, in Corvallis, Oreg.

The work of these centers is from time to time supplemented by special projects located at other insitutions when specialized talents are required. An illustration of this is the one soon to get underway at Lehigh University's Surface and Coating Institute on the separation of water from hydrogels. The purpose of this project is to suggest novel means for improving the dewatering of waste slurries produced by effluent treatment to permit more satisfactory disposal.

Through these regional research centers, all of the waste disposal problems of the industry are, or have been, subjected to productive and continual investigation.

The waste disposal problems of the pulp and paper industry are many and diverse. Different mills produce different wastes, and the characteristics of the receiving waters vary substantially in assimilative capability depending on hydrology and other natural conditions, usage and regulatory control. Thus, in a narrow sense, each situation constitutes a different problem. Through the years, however, an overall and broader concept of the basic problems has emerged. Under this concept, numerous individual problems are susceptible of categorization and solution under the following classifications:

(1) Stream analysis and reoxygenation of rivers.
(2) Suspended solids removal, dewatering, and disposal.
(3) Aquatic biology.
(4) Treatment of wastes for biochemical oxygen demand, (BOD) reduction.
(5) Decolorization of wastes.

The progress which has been made through industry research in each of these areas is summarized below.

(1) Stream analysis and reoxygenation of rivers

The pulp and paper industry was the first to employ stream analysis techniques on a wide scale, for formally analyzing the effects of effluents on receiving waters and for predicting the degree of treatment required to meet given water quality requirements. Through a national council project, begun at Manhattan College and continuing to this time at the University of Michigan, not only was effective use made of existing methods of analysis, but improved techniques were developed. For instance, in addition to forecasting the dissolved oxygen sag curve resulting from the discharge of organic wastes, storage requirements, and discharge schedules can now be prescheduled for locations where runoff is highly seasonal and mill effluent must be impounded for long periods. Such forecasts are of vital importance as existing mills expand in size and new mills must be built in locations exhibiting extreme seasonal fluctuation inflow, especially when there may be extended low flow periods.

The stream analysis techniques developed are widely used for establishing waste impoundment and release schedules. Several large impoundments of this type are used where it is necessary to regulate waste discharge to wide changes in waste assimilation capacity caused by natural variation in runoff and dissolved oxygen content or by peaking operation of hydroelectric power stations.

The basic fact of river reoxygenation is that replenishing of oxygen-depleted water by absorption of oxygen from the air is relatively slow. Restoration of dissolved oxygen removed by wastes through the decomposition of organic matter occurs only through adsorption from the atmosphere. The rate at which it occurs only depends upon many physical characteristics of the stream such as depth, surface area, temperature, rate of flow, and turbulence. For many years, the national council has been prominent in evaluating and seeking means by which the rates of reoxygenation could be enhanced in sections of streams where critical conditions occur.

Mr. DADDARIO. Mr. Knowlton, do you have any examples to show how this has worked out? Have you any successes as a result of reoxygenation work?

Mr. KNOWLTON. I think there is one, Mr. Daddario, near your location in Connecticut, eastern Connecticut that was given a good deal of publicity through the Federal Paper Board where quite some success was realized in the mechanical agitation of a holding lagoon, and I think the results have been quite successful.

Mr. DADDARIO. I think it would be helpful if you could supply for the record some of the productive results of this kind of activity.

Mr. KNOWLTON. I think we can do that. We will be glad to, sir.

(Information provided on this subject may be found in the committee files.)

(2) Suspended solids removal, dewatering, and disposal

The removal of suspended solids from pulp and papermill effluents has probably received more attention than any other phase of stream pollution control, since such solids may interfere with downstream uses, reduce dissolved oxygen levels, or float on the water surface. In addition, the removal of settleable solids is a necessary preliminary to further waste treatment.

The first step taken by the industry toward suspended solids reduction in mill effluents was to remove bark and other wood solids which could be screened from mill effluents, and dried, burned, or disposed of as landfill. Following this, fiber recovery was an important additional objective. Coupled with water reuse, the latter practice has proved to be true conservation measure, since, by these means, water usage per ton of product has been cut to less than 50 percent of that formerly required, substantial heat is saved and about 1 million tons of fiber recovered annually.

For many years, research has been directed toward improving the methods for suspended solids removal from various mill effluents. Four processes are now widely employed for suspended solids reduction. These are sedimentation, contact reaction, flotation, and filtration. All can do an effective job if properly applied under suitable conditions. Through the use of the above-mentioned processes, 95 percent removal of settleable solids and 70 to 90 percent removal of total suspended solids may be attained.

In summarizing progress in the removal of suspended matter from mill effluents, it can be concluded that substantial progress has been made by the pulp and paper industry. However, problems still remain, particularly with respect to the dewatering and final disposal of the large volumes of sludges resulting from clarification. Efforts to find a use for this material have been unavailing, and its disposal is both difficult and expensive. The current practice is to concentrate the sludge to the smallest practical volume and finally dump the material on waste land. The sludge disposal problem is being investigated by the Federal Government, the pulp and paper industry, and equipment manufacturers. However, none of these suggested solutions is practicable, and the accumulation of this material taxes the ability of many plant owners to find disposal areas. This problem will be aggravated with increasing population density.

(Information provided on this subject may be found in the committee files.)

(3) *Aquatic biology*

A considerable portion of the national council's activities is directed to studies of aquatic biology. At the outset, a need was recognized for research in two directions; first, studies to determine the effect of various mill effluents on aquatic life, and second, studies designed to fill gaps in the basic knowledge of environmental requirements. The importance of recreation in our daily lives and the continuing use of our fisheries resources as a food source and means of livelihood, have prompted a number of pulp and paper companies to intensify their individual and coordinated research activities in this field. Attention has also been focused on the problem of organic enrichment of receiving waters, which may result in the occurrence of slime growths in streams.

Many regulatory agencies have established blanket requirements calling for absence of nuisance growths in receiving waters, in addition to the maintenance of certain environmental conditions believed conducive to propagation and successful development of aquatic life. To the extent that the industry can, through research and field study, develop valid information concerning the interaction of mill effluents and aquatic life, it should be able to devise effluent control methods reasonably required to implement the multiple use philosophy for water which is generally recognized as necessary to an industrialized and urbanized society.

A vast amount of research has been devoted to identifying the various constituents of pulp and paper mill waste which may affect the aquatic environment and in what concentrations these constituents alter the character of streams.

Laboratory studies of factors affecting growth of sphaerotilus slimes in water receiving mill effluents have been in progress in the research laboratories of several paper companies, in addition to programs at Rutgers University, Johns Hopkins University, and Oregon State University. The influence of nutrient elements on the occurrence of slime growths has been demonstrated as well as the stream velocities required for such growths to occur. The relative importance of various sugars and of raw and treated sulfite and kraft mill effluents in supporting growth has been established, as have the effects of sanitary sewage, salinity, iron, surfactants and microbial growth inhibitors.

The effectiveness of intermittent discharge as a growth control method has been demonstrated on a laboratory and pilot scale. A full-scale installation has been completed at one mill incorporating facilities for spent sulfite liquor impoundment.

(4) *Treatment of wastes for biochemical oxygen demand reduction*

The oxygen-consuming characteristics of pulp and paper mill waste waters arise from the fact that wood, the basic raw material for paper, is organic in nature. Although wood in its natural state is reasonably resistant to microbial attack, the residues from the chemical pulping processes as well as the various organic papermaking materials are readily decomposed by micro-organisms. The oxygen required by bacteria for the breakdown of the organic matter is referred to as the biochemical oxygen demand, commonly known as BOD.

The discharge of oxygen-demanding wastes to streams presents problems for several reasons. The underlying cause of the difficulty

is that oxygen is only slightly soluble in water despite its abundance in the atmosphere. In pure water, only about eight parts of oxygen may be dissolved in a million parts of water at typical summer temperatures. If this low initial concentration is decreased by much more than about 60 percent, the aquatic environment may be affected. Under conditions of complete oxygen depletion, fish cannot live and anaerobic decomposition may occur.

In view of these undesirable effects, it is necessary for the regulatory agencies to specify minimum dissolved oxygen requirements for a given stream. Unfortunately, the minimum dissolved oxygen requirements set by many States are somewhat higher than authoritative aquatic biology research indicates is necessary.

Unfortunately for the protection of aquatic life, the treatment of pulp and paper mill wastes for the removal of suspended matter does not produce a proportionate reduction in the BOD of these effluents. This is because 65 to 80 percent of the BOD is in a dissolved state and is unaffected by removal of suspended solid materials. Chemical and physical techniques, such as ion exchange, dialysis, and electrical methods to remove the BOD fraction, have been tried and found either economically unfeasible or mechanically impractical. Research conducted by the National Council and others in this field has indicated that the use of biological treatment methods is the most promising method for disposition of the BOD content of these wastes.

Biological treatment may be of two general types—aerobic and anaerobic. Anaerobic digestion is decomposition of organic matter in the absence of free oxygen. In the aerobic treatment processes, bacterial and other micro-organisms oxidize the organic matter in the presence of dissolved oxygen. Oxygen is supplied to these aerobic treatment systems through either natural means, as in some oxidation lagoons, or mechanically in activated sludge plants and aerated stabilization basins and trickling filters.

One of the simpler forms of aerobic treatment is the oxidation lagoon, where the wastes are stored while biological action reduces the BOD. In the Southern United States, substantial BOD removals are being obtained in storage periods as short as a few weeks. The factors affecting the efficiency of this process, such as depth, detention time, temperature, and nutrient addition, were extensively studied by the National Council at Louisiana State University. These studies showed that the detention time to accomplish BOD reduction is greatly decreased if the oxygen transfer from the atmosphere is accelerated by mechanical means. There is a growing tendency, therefore, to diffuse air into lagoon systems. Various techniques are used for this, including recirculation over concrete steps, diffused compressed air, or mechanical aerators which agitate the surface of the lagoon, thus enhancing oxygen solution from the atmosphere. With this supplemental aeration, it is possible to obtain a substantial BOD reduction with 5 to 7 days' storage under summer conditions.

Where large land areas are not available, and a rapid BOD removal method is required, attention of the pulp and paper industry has been focused on the trickling filter and activated sludge processes. In the former method, the wastes are sprayed on beds of stones or another filter medium, on which biological growth are developed. The pas-

sage of the wastes through the filter beds results in the partial oxidation of the wastes.

The National Council has conducted extensive experimentation with the application of the trickling filter process to a wide variety of effluents, ranging from spent liquor to paper machine overflows. While the results of this work show that the wastes tested were responsive to this form of treatment, there still are difficult technical problems to be solved. As the BOD loadings possible with filters are relatively low, high capital costs for the process are involved. These units also have a tendency to clog due to the fibrous nature of the wastes applied, as well as to the form of microbial growth on filter stone produced by papermill wastes. It is because of these limitations that application of this process to pulp and paper mill wastes has not been general.

To date, the activated sludge process, and modifications thereof, in which the wastes are contacted with biologically active sludge in tanks in the presence of oxygen have appeared to offer the best methods for satisfying the oxygen demand of pulp and paper effluents where a high degree of BOD reduction is required.

The national council research project at Louisiana State University first demonstrated that kraft mill effluents could be stabilized at greatly accelerated rates using this technique. Since this initial work on kraft wastes, activated sludge experiments have been conducted on practically all types of pulp and paper effluents, it has been found that substantial BOD removals are attainable with most wastes at detention periods of 4 hours or less. The rate of oxidation with these effluents is normally higher than with sanitary sewage because of the higher temperatures at which oxidation takes place and because of the improved aeration and sludge-effluent contacting methods employed.

With respect to aerated lagoons, the national council project at Johns Hopkins has been especially active in developing this technology. For locations where the limited requisite land area is available, accelerated aeration in reasonably short periods, that is, 5 to 10 days' retention, provides an effective means of oxidizing the waste.

BOD reduction is adjusted to meet dissolved-oxygen conditions in the receiving stream. Storage oxidation basins achieve in general from 30 to 80 percent BOD reduction, depending on storage time, season of the year and depth. Aerated stabilization basins are generally designed to remove 60 to 80 percent of the BOD, activated sludge units 80 to 85 percent, and trickling filters 40 to 60 percent.

(5) *Decolorization of wastes*

In the treatment of pulping wastes for suspended solids and BOD removal, one characteristic; that is, color, usually remains unchanged. The brown color of pulping effluent is due to the presence of lignins and tannins dissolved from the wood during digestion and bleaching. Persistence of color downstream in the receiving waters is due to the resistance of these compounds to microbiological degradation.

The importance of color, although largely aesthetic, also involves technical considerations in connection with its possible effects on water treatement for public water supplies and on process water quality.

In many sections of the country, particularly the coastal areas of the Southeast, swamp drainage imparts a natural high color to the rivers. This color is chemically similar to that of pulpmill effluents, both being derived from the extraction of lignins and tannins from wood. In these regions there is little or no objection to increased color of streams which are already naturally colored.

However, in the cases of mills discharging to headwaters of otherwise lightly colored streams, particularly those serving as public water supply sources, the discharge of colored wastes may be objectionable. Insofar as fish life is concerned, all available information indicates that the effects of these materials are negligible.

Attempts have been made to adapt biological treatment processes to the oxidation of color bodies but these have not met with success. The matter of decolorization of colored pulping wastes appears to need continuing research, since at the present time no practicable methods have been demonstrated.

Turbidity, due largely to inorganic materials, can cause unsightly opalescence in receiving waters. Extensive research on clarifying such dispersions is conducted at the Western Michigan Center. Removal of such turbidity from some wastes is readily accomplished, but from others, results of treatment is erratic and the coagulants required costly.

As previously stated, techniques have been developed and are now available to treat most industry wastes. Future research activities by the paper industry will be devoted to developing more sophisticated treatment methods. Increasing research attention is being given to the treatment techniques devised for the purpose of reclaiming waste water, so that it may be utilized in an ascending scale of uses, both in the mill and more generally as for municipal purposes.

Research is also being increased on development work, through which methods developed in the laboratory are made available for actual mill use.

I would like to continue from another statement that isn't printed.

Mr. DADDARIO. Please proceed.

Mr. KNOWLTON. For the record, I think it is pertinent to state that the national council alone budgets in excess of $250,000 per year for research in the above-mentioned field. Beyond that we are making available further funds for extension of these projects as opportunities permit.

As a matter of further interest, we are currently negotiating with the Water Pollution Control Administration a joint project on the subject of decolorization. I believe that this joint approach may well be the most satisfactory way of attacking many of our most difficult problems.

Two weeks ago a formal statement of the position of the American Paper Institute was presented by Mr. William R. Adams, chairman of the institute and president of St. Regis Paper Co., accompanied by Dr. Malcolm Taylor of Union Camp Corp., and Mr. Charles Hickey of West Virginia Pulp & Paper Co. The statement was presented to the House Committee on Public Works. This statement gave strong endorsement to the proposals and provisions of H.R. 16076 for grants and contracts for research development and administration of ad-

vanced waste treatment and water purification methods, as well as research for new and improved methods of joint treatment systems for municipal and industrial wastes. I fully agree that this is a mechanism that most probably will result in the earliest solution of some of our most difficult problems.

Mr. DADDARIO. Mr. Knowlton, what part of your whole research effort does this quarter of a million dollars make up, what percentage?

Mr. KNOWLTON. I think that would be a very difficult question to answer because it is the largest budget in this area of the industry associations mentioned, but as of the moment we have no means of knowing the magnitude of the individual company research effort. Do you have any index of that, Mr. Gehm?

Mr. DADDARIO. How does it relate itself to other research work being done in this joint way? How much research is being done in this field separately by any of the companies in the industry and how does it relate to the overall research effort for all purposes?

Mr. KNOWLTON. Do you have any comment on that?

Dr. GEHM. Yes. There is a large amount of money spent by individual industries on research and development. Some of it is spent indirectly by our organization in cooperative work such as pilot plant work where the mills build the pilot plants and we operate them and conduct the studies. As an educated guess, I'd estimate that five times the total spent by the council is spent by individual companies.

Mr. DADDARIO. I would appreciate if you would check this and make these comparisons because it would give us a good idea as to the magnitude of the effort and the way it looks as we take some kind of a bead on the future.

Mr. Knowlton, this morning we have gotten divergent points of view on the multiple use of our environment. There is a conflict among users; there are economic voices versus conservation voices. Both positions are based somewhat on scientific data available, and we sit here trying to get information together so we can come up with a political solution. As a result we can probably classify ourselves as political scientists. Others are looking to us. Those who are working in industry, and those in the conservation area offer their expert opinions and we must come to some kind of a balance between the two, because they seem to be somewhat in conflict with each other.

Mr. KNOWLTON. I think from the broad philosophical standpoint, Mr. Chairman, that there is in existence a mechanism to make a start on this problem; namely, coming from New York State I am quite familiar with the approach to the total water resources planning that is currently being undertaken there. Our approach is based on a stream standards philosophy. Stream standards, of course, are similar to land zoning. We feel that the use of streams for waste assimilation within this capacity is a legitimate use of water, of our water resources, and this has to be qualified by the capabilities.

The New York approach, the New York law provides for zoning of the streams, assignment of standards by classification to the best usage of the streams.

Now, this does not preclude future upgrading and, as a matter of fact, the State of New York is in the process of upgrading all E and

F streams to a minimum of D. Now, we have a classification that goes from a double A down to E and F. E and F are going to be eliminated.

In 1965, the Congress enacted the amendments to the Water Quality Act, I think it was P.L. 89–234, which provided a mechanism for the Federal Government to stimulate the States that are not so far advanced in this concept, to come up with standards. In other words, the Federal Government is putting a floor under the standard qualities and asking States to enact their own programs to equal or better that. I think this mechanism is sound. I think that the best administration of the water resources can be handled at the local level, at the State level, but I think the Federal Government has a real role to play in stimulating the States to do this.

Second, I think the Federal Government has a very real role in stimulating the training of manpower because as was brought out in your discussion with Mr. Raynes, there is a woeful shortage of manpower and no program is worth anything if you don't have the men to do it.

I know, for example, in New York State that our own department of health is staffed at a level of somewhere 25 to 30 percent of the engineers authorized in their table of organization. I think the Federal Government through its broad educational interests can stimulate the training of more people in this field.

A third area is that which we are concerned with here; namely, research. I think many times the Federal Government in conducting research on its own without reference to industrial applications is perhaps wasting time and money.

On the other hand, as I pointed out in my concluding remarks, the approach to joint solution of problems is a very possible mechanism to attain these ends. The specific problem to which I had reference has to do with decolorization of wastes, and I think it was just within the last 2 days that Dr. Gehm sat down with Dr. Weinberger of the Water Pollution Control Administration to explore further the details of the arrangement into which we are entering.

Does that answer you somewhat?

Mr. DADDARIO. Yes, I couldn't help but bring up this point considering the two papers which have been presented to us. I'm pleased to see that Mr. Raynes hasn't left. I wonder if he might be willing to give us his opinion on this matter. Why don't you come forward, Mr. Raynes?

Mr. RAYNES. Would you please restate the question?

Mr. DADDARIO. We have heard here today about multiple uses of our environment. Would you comment on the conflicts between uses between the economic voices and the conservationist voices? Is there a balance or a meeting place which can be of help to us as we approach a point where we have to make a political decision?

Mr. RAYNES. Well, I hope to be both a conservationist and a worker actually doing something about pollution. It isn't enough, in my opinion, for industry just to say, "We have a right to dump our waste," and it is not helpful for conservationists just to say, "stop." I think someone has to be working toward the solution to the problem. Everyone should be working at it.

Mr. DADDARIO. This is why I ask the question, because we have got to certainly be pointing to some balance.

Mr. RAYNES. I happen to disagree with the philosophy that streams are to be made to assimilate waste. I think that is a concept which is no longer valid. I tried to listen to your paper, Mr. Knowlton. When you talked about technical difficulties, you always seemed to come back to the fact that it costs too much. There are two different problems as I view it. One is a technical problem of can you treat the wastes adequately and the other one is how much it is going to cost to treat it. What I am trying to do in my work is to make the cost as little as possible, and I'm accepting tacitly it is going to have to be done. And, if industry were doing the same thing, I think we would come to reasonable solutions a lot quicker.

Mr. KNOWLTON. I differ with you, sir. I think we are taking this approach, but you cannot separate the cost from the technology.

Mr. CONABLE. You certainly can't separate the cost from the technology until there is some sort of subsidy available in the event the cost exceeds the economics of the situation. We can't expect our industries to go out of business simply to have clean streams.

Mr. KNOWLTON. May I inject at this point that, of course, this is one reason why in a marginal area where it can be demonstrated that the application of technology would put an individual enterprise out of business, this can often be worked out if given some time, and a willingness to work together. This can be best handled, I think, at the State level rather than from the Federal Government level.

Now, I would like to comment here on a situation in Monroe County, in New York State, which Mr. Conable knows quite a bit about. There is a very strong conservation movement within Monroe County that has resulted in some rather extreme positions being taken both by the individuals involved and some of the State legislators. And, there has been a great deal of agitation to upgrade many of the classified streams in the county. This subject became of such widespread interest in Monroe County, that a grand jury was convened this last winter and spring and published a report in June.

Mr. Conable, you may have seen that report.

Mr. CONABLE. Yes, I have.

Mr. KNOWLTON. And, they make to me what is a very sensible point. Certainly it is desirable to constantly upgrade. And, they commend the public interest that is agitating for this objective. However, they say, "Let's come up to where we are supposed to be now before we talk about upgrading."

In other words, the streams involved are not meeting the current standards of classification. The sources of discharge are in process of developing treatment means, but let's get to that point before we start talking about going further. And, I think this same philosophy can be applied on a nationwide basis. Let's come up to a reasonable level before we start talking about going further.

Mr. DADDARIO. On page 5 of your statement, you said you are looking for methods to improve the removal of suspended solids from various mill effluents. You say efforts to find a use for this material has been unavailable and disposal is both difficult and expensive. When we find areas such as that where research has been ineffective, should

we not establish it as a goal to be accomplished and make extra expenditures to solve the problems?

Mr. KNOWLTON. There's no question about it, and it so happens that this is one of the two problems in which it was decided last fall to double our research efforts within the national council organization; this, and the decolorization as being the two most critical problems. One of the problems here again comes back to manpower. The state of the art of sludge disposal dewatering is fairly advanced to the point where there are only very, very few authorities in the country capable of carrying the work further. And, Dr. Gehm has spent some time during the winter and early spring exploring the available people to undertake this type of project. And, in fact, before we reach that point, we spent about 6 or 8 months tabulating and compiling the known technology to date. This is now available and if it would be of interest to your committee we will be glad to submit a copy of it to you.

(Information provided may be found in the committee file.)

Mr. DADDARIO. It would be very helpful if you would. So that we can to a judgment as to what kind of problems there are in creating support for this kind of activity, do you find it difficult to get funds from your participating companies as you seek to increase your efforts in this area? Have you had resistance or not?

Mr. KNOWLTON. Increasingly less resistance. Of course, in view of the current political climate and the interest in this subject over the last 2 or 3 years, individual companies are more and more feeling the pressures both from the Federal level and from the local level and recognize that where they don't have the solution to problems, they are willing to cooperate and contribute in larger amounts to the joint efforts.

I think that we are, as I say, spending in excess of a quarter million dollars this year. It is not practical to say: "Well, let's double that immediately because you have to implement it." And, I think, however, by next year that this sum will be quite significantly increased as the opportunities present themselves. Because, not only do you need the personnel, but you have to map out the direction in which you are going, and these projects are best undertaken at educational institutions where you have acknowledged and qualified scientific leadership along with the graduate students to do some of the legwork.

Have I put that about right, Dr. Gehm?

Dr. GEHM. Very good.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. You referred to Monroe County, N.Y., Mr. Conable's interest. I happen to have Monroe County, Mich., in my constituency and I would say that those who live there are most unhappy with the performance of the paper and pulp industry in terms of pollution of streams and of Lake Erie. The local officials have been extremely reluctant to clamp down on obvious pollution because they feared the loss of the industries and therefore they have not used the authority which they have under the law.

On pages 5 and 10 of your statement, you quoted the figures on the performance of various types of abatement systems. On page 9, how-

ever, you really have quoted the principal questions, and they are the following:

High capital cost for the processes involved. And, the answer is, "Some of the mills in my own district have not invested the capital," and second, even more important, next sentence, you say, "The units also have a tendency to clog due to the fibrous nature of the wastes applied," and so forth. My experience has been that if I go down to those plants when nobody knows I am coming the treatment system is turned off and the flow goes directly from the mill to the river. When I go on a formal visit, everything is working and the water is churning through.

Some improvement is needed because the river basin which is the dumping point—and this flows directly into Lake Erie—is so bad that when you go through on a powerboat, the paper wastes float up to the top of the river and the smell is extremely offensive.

In other words, there is no question about the pollution: There is no question about the level of trouble. There is no question about the fact that the BOD is out of sight. There is just simply no question about the fact that the papermills in that area have turned the river into a sewer. The question is, Who is going to do something about it? Part of the answer concerns the subject of technology which we are all discussing today. The question I have is, Why do you try to concentrate these wastes either in water or on land instead of dispersing them over land? Water is, in a sense, a very poor place for treatment of chemical waste, particualrly when it is a stream or river. Why do you not dispose of this over acres of topsoil and let the natural biological work of the forest or farm take care of the waste?

Mr. KNOWLTON. Well, you pose several questions. Taking your last one first. Particularly in urban areas there aren't acres of ground ecessary. A lot of work has been done in spray irrigation.

Mr. VIVIAN. You say in urban areas but the fact of the matter is there is no reason why you can't truck or pipe these wastes to nonurban areas. There's no necessity to solve the problem in the amount of acres owned by the papermills at the persent moment.

Mr. KNOWLTON. Perhaps if the land is available, but this touches again on the cost element. I think we must not lose site of the fact hat the disposal of wastes in streams has been something that has gone on ever since the beginning of man on this planet and it has been nly within the last 3 or 4 years that there has been this sudden realization that this has to stop and you just can't turn around there in a urry. Now, going back to your individual case, the significance of he mill which all the valves were turned over.

I know nothing about this. If this was a deliberate situation, I nd no excuse whatsoever for it. On the other hand, no piece of mehanical equipment is going to operate 100 percent of the time, 365 ays of the year.

Once in a while, something breaks. You may have been there at time when this happened.

A second point you raise, why water is a poor medium to use—that ay be but water is the medium in which paper and pulp are made. It s the basis of the process, therefore, you have not only the waste that t carries but you have the water itself.

Mr. VIVIAN. Excuse me. I have no objection to the use of water in papermaking processes. I do have objections to its use in the waste treatment process.

Mr. KNOWLTON. Yes, but the water has to go somewhere and this is in the river. Efforts have been somewhat successful in reducing the amount of water that we are using in making a ton of paper. In fact, it has been more than cut in half in the last 20 to 25 years.

Mr. VIVIAN. Has the amount of material dumped in the water gone down?

Mr. KNOWLTON. Yes. I think there has been a reduction of 60 percent in the waste load contributed to our streams in the last 22 or 23 years, the duration of the council's existence in the face of an increase of production of two and a half times. We are making two and a half times as much paper now as we made in 1943 and the waste load contributed to our streams has been reduced by a factor of some 60 to 65 percent.

So progress is being made. Now, insofar as the stuff that is brought to the surface as your motorboat goes by, we can't deny the fact but there has been accumulation over many, many years of these sludges which we are now attempting to stop putting in but those that are already there, are going to take a long time to get rid of. Another point that you make and I think this is true in Michigan.

Mr. VIVIAN. By the way, that river is dredged almost every year so you are physically removing the wastes.

Mr. KNOWLTON. But this becomes another part of the sludge disposal problem, where do you put it?

Mr. VIVIAN. Out in the lake obviously, where it is even more trouble.

Mr. KNOWLTON. This isn't right either, but you are also going to run out of holes to put it in. But as far as the paper industry in Michigan is concerned, I believe that the mills in the area that you talk about have all signed agreements with the State authorities——

Mr. VIVIAN. That is correct.

Mr. KNOWLTON. To understake abatement procedures. Now, these take time. There is manpower, available equipment, planning, design, and so forth. But I think progress is being made. Does this answer some of your questions, Mr. Vivian?

Mr. VIVIAN. It answers some of my questions, but it does not soothe all of the irritations. I would like to comment further on this.

I would like to ask if the use of the rivers and streams as places to vent chemical and biological wastes may be inappropriate as compared to large areas of land. It was said that there are not acres of land next to some of the mills. I think in my own case, there are thousands of acres available only short pipeline distances away. The question I come back to is over the long run, is it not better to use the surface of the ground which is extremely active rather than the streams?

Dr. GEHM. I would like to answer that.

The paper industry has some 30 installations of this type, generally spray irrigation in operation at mills today.

However, you can get rid of as a rule, of about 10,000 to 20,000 gallons per acre per day. Some of the large mills use 60 million gallons of water a day, so you can imagine the acreage that would be involved

in their case, hence we feel it is not practical for large mills but it is a very useful tool for many of our small ones and will be put to additional use in the future.

(Information provided on this subject may be found in the committee files.)

Mr. VIVIAN. In other words, you are actually making use of such processes?

Dr. GEHM. That is right.

Mr. VIVIAN. Is this in the North or in the South?

Dr. GEHM. Both. There is quite a number of them for example on the Miami Valley in Ohio.

Mr. VIVIAN. Now, if for example, the performance of the various treatment plants is around 70 or 80 percent—I am just remembering the figures on pages 5 and 10—and if the volume of paper produced rises as you say it is rising, this means that the total amount of waste deposited in the stream may well go up even though fairly good treatment plants are being used. In other words, even a percentage like 70 or 80 percent pure, still means an enormous quantity in terms of tons being dumped in the streams. When will you realistically be able to set yourself goals like 99 percent?

Mr. KNOWLTON. Without answering your question directly yet, Mr. Vivian, I think it is true that virtually all of the new installations that are being built today and over the recent few years, there has been no problem, the treatment plants have been built into the original plans and the effluents from these mills are in pretty good shape. The real problem is how do we fix the old ones and bring them up to line.

Now, it has been estimated, and here we are tossing big figures around, that it will cost industry something approximating a billion dollars to bring present installations up to where we want them. If this is done over a period of 10 years, this is an average expenditure of a $100 million a year. But as Mr. Hickey of West Virginia pointed out in testimony before the Public Works Committee, the total profit picture of the paper industry is somewhere in the neighborhood of $300 million a year, so what we are saying is that if we have to superimpose the application of one-third of the total profits of the industry into this problem, this is economically a pretty big job and it is probably not going to be practical.

Furthermore, a large segment of this $300 million of profits is coming from the newer plants that don't have the problem ahead of them. Therefore, there may be cases where it would take the total return, total profit of a mill applied over the next 2 or 3 years in order to accomplish this result.

Now, this is not consistent with our basic economic philosophy and so you have this problem and I come back to you again, you cannot separate the technology from the cost. You have got to have the dollars to do it.

Now, I know of an incident of a small marginal paper mill in New York State that has gone out of business. It was on a stream, took the whole stream in one end of the mill and put it out the other end and it was a mess. It was a nuisance. The mill was a marginal mill. It was breaking even. It was faced with the cleanup and this, coupled with other economic aspects, caused the ownership to decide to put it down.

Now, they did not make the effort of cooperation. They fought i all the way through the courts and I think nobody was sorry to s them go out of business and it so happens that the individuals wh were working in that plant now have other occupation in the vicinity so there has been no loss from the employment standpoint but this can happen, and I plead that where you have marginal operations, programs can be worked out but they have to take time. Otherwise, the communities involved might lose a major source of income, and thi is the real problem. It is not the big new mills. It is the oldtimers that are causing this.

Mr. DADDARIO. Gentlemen, I have got to advise you all that Mr. Knowlton has a 1 o'clock plane reservation.

Mr. KNOWLTON. Mr. Chairman, I'll stay just as long as you need me.

Mr. DADDARIO. We can get further questions to you and I know how difficult it is to get from one city to another these days.

Mr. VIVIAN. Mr. Chairman, I have about 2 minutes worth of questioning in mind. The mills in my area happen to be between 40 and 50 years old. Therefore, they have the problems of old mills. However, they have accumulated profits over that time and have amortized their costs over 50 years.

Mr. KNOWLTON. Excuse me. Section 531 of the Internal Revenue Code does not permit you to accumulate profits.

Mr. VIVIAN. They have produced profits which could have come back into the business for pollution reduction. That code I totally agree with. Therefore, you are in a position of continuing improvements over the future as well as in the past. Maybe 10 years of improvement doesn't necessarily represent 10 years of profits. I point out that the economics are nowhere near as bad as they seem from the comments you just made.

The second question I would like to ask you is, What requirements are being placed on the mills you have next to the ocean? Are you being required to upgrade the quality of the effluents going directly into the ocean?

Mr. KNOWLTON. I think this is particularly true in the Puget Sound area.

Dr. GEHM. Yes, sir.

Mr. VIVIAN. Is it true? Where in Georgia, for example?

Mr. KNOWLTON. In Savannah, agreements have just been made for treatment.

Mr. VIVIAN. I would like to go into that subject further in the record. What treatment is required for plants whose effluent flows directly into the sea?

Mr. KNOWLTON. I would like to make this point that progress is being made. It is time consuming. From all the factors that we are talking about, in other words, there is no point in saying, "All right, tomorrow we will go out and spend a million dollars to do this." You have got to get the engineering done and you have to have the basic surveys, Mr. Raynes, in advance, in order to know what you are doing in order to apply the engineering and this all takes time. The New York State program of pollution abatement involves a series of conferences with each source of discharge. These conferences attempt

to set up agreed upon timetable and in 90 percent of the cases to date this has been done. The timetable of employment of a consultant if one isn't available already, the development of preliminary plans, the approval of the plans, the development of final plans, and finally construction and operation, and these timetables stretch out into a matter of 3 or 4 years and I think if we take any given locality in this country, and we will look at the individual establishments in each area, that they are better off today, they are farther along this timetable than they were a year ago or 2 years ago.

Mr. CONABLE. Mr. Chairman?

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Are there other industries that belong to the National Council for Stream Improvement or is it just for the pulp and paper industry?

Mr. KNOWLTON. No; it is entirely pulp and paper.

Mr. CONABLE. Do other industries have similar organizations? For instance, do you know if the steel industry has any?

Mr. KNOWLTON. I think they have these activities within the overall trade associations. I don't believe there is another industry that has a research and engineering organization, or an organization devoted entirely to research and engineering.

Mr. CONABLE. Does this situation exist because the pulp and paper industry has a much more acute problem in the pollution area than other industries?

Mr. KNOWLTON. I don't think so. Would you say so, Doctor?

Dr. GEHM. Not necessarily.

Mr. KNOWLTON. But I know that manufacturing chemists and I believe iron and steel and petroleum participate in this activity within the associations.

Mr. DADDARIO. Food producers?

Mr. CONABLE. Are we going to have any other industry representatives during these hearings?

Mr. DADDARIO. Yes.

Mr. CONABLE. Well, that's all, then, except I would like to thank Mr. Knowlton for a very specific statement. It has been very helpful, sir, and we appreciate your comments.

Mr. KNOWLTON. Thank you and, Mr. Daddario, I would like to say that we in the industry are completely in full cooperation with what you are trying to do and we stand ready to be of any assistance we can. We will come down here again and give you facts and figures at any time.

Mr. DADDARIO. Mr. Knowlton, we appreciate that and we certainly do intend to contact you further so that we may get answers to additional questions and help as we go along.

(Additional questions and answers for the record may be found in vol. II.)

Mr. DADDARIO. We are interested in an overall improvement of effort—that's well demonstrated in the record. The fact that we had you and Mr. Raynes here today is helpful, because even though there are some obvious conflicts in your testimonies, I think you can see a great deal to be pleased about insofar as direction and concern are

at issue. We are pleased to have had you and we are sorry that you have to run off. So do we. We have just been called to the House.

(Biographical statement on David C. Knowlton follows:)

BIOGRAPHICAL STATEMENT ON DAVID C. KNOWLTON

Born: February 8, 1910.

Education: Hotchkiss School—1927; Princeton University, A.B.—1931 (Phi Beta Kappa) (Magna cum laude).

Marital status: Married Jane Elizabeth Lee, of Rochester, New York, 1935; three children—two daughters, one son.

Home address: 341 Flower Avenue West, Watertown, New York.

Business experience: Since 1931 with Knowlton Brothers, northern New York's oldest industry with a history of over 150 years and the third oldest paper mill in continuous operation on the same site in the U.S.A. Fourth generation of Knowlton Family to be connected with Knowlton Brothers. Elected secretary of the company in 1941, Vice-President in 1944 and in 1948 President and Chief Executive, a position currently held.

Industry affiliations: Past President of Specialty Paper & Board Affiliates 1959–60; Director, American Paper Institute; Member of Government Relations and Air and Water Resources Committees of American Paper Institute; Chairman, Board of Governors of National Council for Stream Improvement of the Pulp, Paper and Paperboard Industries, and the Chairman of the Operating Committee; Trustee, Institute of Paper Chemistry; Past President, Association of Pulp Consumers (1952–53); Member, Joint TAPPI–APPA Advisory Committee to Forest Products Laboratories; Director, Associated Industries of New York State, Inc.

Other business affiliations: Director, Marine Midland Trust Company of Northern New York; Trustee, Jefferson County Savings Bank; Director, Beebee Island Corporation; Director, Conde Hardware Company; Director, John Weeks & Son Company.

Government affiliations: Industry Advisory Member—N.Y. State Water Resources Commission; Member, N.Y. State Health Department Industry Advisory Committee on Water Pollution Control.

Community activities: Trustee, Emma Willard School, Troy, New York; Elder of the First Presbyterian Church; Trustee, House of the Good Samaritan; President and Trustee, Watertown Cemetery Association; Past Chairman, Jefferson County Chapter, American Red Cross; Trustee, Citizens Public Expenditure Survey, Inc.

This committee will adjourn until 10 on Wednesday next.

(Whereupon, the committee adjourned at 12:25 p.m. to be reconvened at 10 a.m., on Wednesday, August 3, 1966.)

THE ADEQUACY OF TECHNOLOGY FOR POLLUTION ABATEMENT

WEDNESDAY, AUGUST 3, 1966

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The committee met, pursuant to adjournment, at 10:10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our witness this morning is Mr. William E. Warne, director of the Department of Water Resources, State of California, and I understand Mr. Warne, that Mr. Dillon is here with you.

Mr. WARNE. Yes, Mr. Chairman. Mr. Tim Dillon is here with me.

Mr. DADDARIO. Would you proceed, then, Mr. Warne.

STATEMENT OF WILLIAM E. WARNE, DIRECTOR, DEPARTMENT OF WATER RESOURCES, STATE OF CALIFORNIA; ACCOMPANIED BY TIM DILLON

Mr. WARNE. Mr. Chairman, members of the committee, my name is William E. Warne. I am the director of the water resources, State of California, a position which I have held under appointment of Gov. Edmund G. Brown since the 1st of January of 1961. I also am a member of the California State Water Quality Control Board, a board on which I have served for some 8 years, and a member of various other agencies of this sort in the State. I served one term on the President's Water Pollution Control Advisory Board, a 3-year term which terminated a year ago.

My presentation today is divided into two parts. In the first part I will discuss areas where we feel inmprovements in technology are needed for a better understanding of pollution problems, and I will place particular emphasis on the pesticide and fertilizer pollution of lands in the San Joaquin Valley.

In the second part I will discuss the administrative and policy problems encountered in applying technology at the State and local levels, as these subjects are listed in part E of section VI of the report of the Research Management Advisory Panel, "The Adequacy of Technology for Pollution Abatement."

Although the subject of pollution abatement is broad and complex, my presentation will be limited, for the most part, to water-related matters. We all recognize that pollution must be viewed as it relates

to the total environment—land, air, and water—rather than as it may affect just one of these resources.

With the ever-increasing demand for water in California the size and complexity of our water developments have steadily increased. The reuse of water has become commonplace, and quality has emerged as an element as important as quantity.

Now, after we have been developing these western water supplies for 110 years, in our State, the problem of gradual deterioration of the quality of water through reuse is becoming critical. Downstream users are in controversy with upstream users in many river basins of the irrigated west. In the future many more streams will be affected.

Your committee should be commended for getting the quality problem out where it can be studied and considered now, rather than waiting until it has grown to such proportion that it will be possible of resolution only by extended litigation.

Major efforts are being made in California to evaluate the significance of the following water-quality-related factors which influence the usability of our water resources: first, drainage wastes; second, nutrients; third, pesticides; fourth, detergents; fifth, waste reclamation; sixth, desalination brines; and seventh, solid wastes.

The amount of salt which accumulates in root-zone soils must be maintained at a fairly low level or crop growth can be inhibited. Experience gained throughout the world has shown that irrigated lands in arid and semiarid regions of the world deteriorate unless adequate drainage is available.

For the committee's information, as a basic point, our California agriculture is about 95 percent irrigated agriculture. At least the values of the crops from irrigated lands run about 95 percent of the total. We have about 8½ million acres irrigated in the State and California has a gross crop value plus livestock value of about $3,600 million a year. We are the leading producer among the 50 States. The problem then of the care of the soils under irrigation is particularly important to California, and it is also growing acute.

When the mineral content of drainage waters rises to levels that make it no longer suitable for reuse, even though the water may not be contaminated so far as health is concerned, it must be returned as directly as possible to the sea. Otherwise, it can poison the land with its accumulated salts. Evidence of the progressive deterioration of water caused by continual reuse may first appear in critical degree in a single area downstream, but the problem and its solution are not restricted to that immediate area and may be basinwide or even interbasin from the first.

The accumulation of salts in the soil profile, as well as the development of high water table conditions, has made it impracticable to farm extensive portions of the Indus River Valley in India and Pakistan as well as about 25 percent of the Delta of the Nile.

Mr. VIVIAN. Mr. Chairman?

Mr. DADDARIO. Yes.

Mr. VIVIAN. Are you suggesting that these areas are recoverable?

Mr. WARNE. Yes.

Mr. VIVIAN. In other words, wouldn't it be possible to increase the agricultural output of those nations by desalinating the soil?

Mr. WARNE. Yes; that is true and there are extensive programs underway at present, for example, in Pakistan, with this as an objective.

Mr. VIVIAN. Do these programs have a good research base?

Mr. WARNE. I think they have a pretty good research base. I don't know that one can say that they have been carried far enough so that you can demonstrate that they are going to be fully effective, but we believe they can be effective.

Mr. VIVIAN. It seems to me that it might be cheaper for us to assist them in this way than to supply them with foods that can be grown on their own soils.

Mr. WARNE. We are assisting in part in this effort through our international aid program in Pakistan.

Mr. DADDARIO. Aren't private foundations contributing also?

Mr. WARNE. They are, and numbers of our contractors for example, general contractors are working in these areas. I think the World Bank is also participating.

In our country, as well as in foreign lands, we find examples of quality problems related to drainage. Coachella and Imperial Valleys in California already have recognized the need for drainage and have installed many miles of subsurface drainage lines to carry leachings from irrigation waters to the Salton Sea.

The Imperial Valley landowners have installed some 10,000 miles of subsurface tile drains. In addition, the Imperial Irrigation District has constructed 1,400 miles of collector canals to provide drainage for some 250,000 acres of land.

The drainage problem in the San Joaquin Valley is just developing, but its solution is important to the agricultural economy of the State and Nation. The significance of this statement can be recognized when one realizes that the agricultural income in 1965 for the 8 counties within the valley was greater than the agricultural income of all but 3 of the remaining 49 States, the exceptions being Iowa, Texas, and Illinois.

We have recognized the existing drainage problem in the San Joaquin Valley and have been making studies to determine the degree to which the problem will be intensified by deliveries of water from the Federal-State joint project.

I refer here to the San Luis division of the Central Valley project of the Bureau of Reclamation and the State water project which will supply something like a million and a half acre-feet of water into the southern end of the San Joaquin Valley for irrigation. We have a cooperative undertaking in this particular joint development. We already have plans for constructing a drainage facility to convey and dispose of the drainage waters from the valley to the tidal waters of the Sacramento-San Joaquin River Delta.

Dr. Warren R. Schoonover of the University of California has made an independent study of the need for drainage in the San Joaquin Valley, and in his report of April 1965 he pointed up the urgent need for building facilities to avoid development of a drainage problem in the San Joaquin Valley. He further reports that the drain can be built with a discharge at Antioch Bridge without any significant contribution to delta and bay pollution—I'm referring now to the San Francisco Bay—for a decade at least.

Studies made by the department of water resources are in substantial accord with Dr. Schoonover's report; however, some of the agencies located near the proposed point of discharge are worried about the possible effects of drainage waters on their water supplies.

Before the drainage wastes are discharged to tidal estuaries, we are making intensive studies to measure preexisting or "baseline" quality conditions so that the influence of the drain waters on the prevailing environment can be assessed. This aspect has resulted in numerous differences of opinion because of the lack of generally accepted methods for defining "baseline" conditions for some of the materials which may be carried along with the drainage waters, particularly nutrients and pesticides. These latter materials will be discussed in more detail later.

Financing the proposed San Joaquin master drain is another matter which has caused considerable concern. Nearly everyone agrees to the need for drainage facilities; most disclaim responsibility to pay for them. We are now working on a repayment plan which incorporates the concept of apportionment of costs both to specific and to general beneficiaries. Under this plan, a portion of the costs would be repaid by the persons who actually divert drainage waters into the drain. The remainder of the costs would be repaid by levying a tax on all of the tributary lands within the basin.

Mr. DADDARIO. Mr. Warne, on page 4 of your testimony you refer to Dr. Schoonover's independent study in which he reports that, "the drain can be built with a discharge in the Antioch Bridge without any significant contribution to delta and bay pollution for a decade at least." The question comes to mind, are we accomplishing anything if we are merely forestalling a problem for another 10 years?

Mr. WARNE. We anticipate the extension of the drain further west as required and when required. We already are endeavoring to work out what we call a regional waste disposal program which will include the delta, and the San Francisco Bay area and communities, all the drainage area of the San Francisco Bay.

The thought is that eventually an outfall, perhaps more than one, and a collector system will serve both the agriculture drain and the industrial and municipal drains from the bay communities, carrying the wastes clear into the Pacific.

Now, this doesn't seem to be needed at the moment, but the day will come, we feel certain, when a really extensive program of this sort which will combine the disposal of agriculture wastes and of municipal wastes likely will be needed.

The present discussion actually is not between a drain with an outfall at Antioch Bridge and the ultimate disposal plant, but rather between a drain with an outfall at Antioch Bridge and one that might reach as far west as Port Chicago, which is downstream from the Antioch Bridge.

Mr. DADDARIO. However, can we continue to adjust to the amount of discharge which any stream or bay along the coast can take and then assume that sometime in the years ahead we can move into another area as the old one becomes contaminated to the point where it can no longer sustain such a discharge? Don't we need to get more to the source? For example, we have heard testimony before this committee

that we must not try to establish a standard to determine how much waste material a river or body of water can sustain, but rather we should discourage the discharge of anything of a derogating nature into any stream.

Mr. WARNE. Well, I agree, I think, with the philosophy that there isn't any right to pollute. That what we need to do is to preserve the waters for all purposes, both at a quality and quantity that will satisfy the needs of a society that is using them and I certainly would not make any exception of the San Francisco Bay in this regard. It is a prime area of California.

The main constituent in the drain waters from the San Joaquin Valley is going to be chloride, and, of course, the bay is already salty so that we aren't doing anything to the bay by putting more salt into it. This drain water won't be as salty as the bay water that receives it. On the other hand, I don't think that we could possibly stop the accumulation of waters in the San Joaquin Valley that are waste waters and must need be disposed of. Do you see? Our alternatives do not, it seems to me, include either to cease irrigating or to destroy the bay.

As a matter of fact, we can't stop the accumulation of salty water without stopping the irrigation of the valley. So our real problem is to collect and manage the disposal of the water in a way that will not damage the living conditions or the economy of associated areas in the State, the valley, or the bay.

We believe that we can do this with the planning that we presently have underway.

Now, I am an irrigationist. That is, I think, my principal specialization. There are many irrigationists who contend that there is no indefinite life in an irrigation area. That all irrigation areas grow old and die. That's a fate that we don't look forward to in our State. We believe that we can extend indefinitely the life of the irrigated areas of the State of California by proper management, both of the water put on the land and the water removed from it. I don't see that we have any other alternative than to plan to do so and to prosecute programs designed to achieve these ends.

Mr. DADDARIO. This is true, but on the other hand, you can't stop what you are doing. There needs to be progress, and while you are maintaining this agricultural production level, discharges will continue with resulting problems.

Mr. WARNE. There are some problems.

Mr. DADDARIO. One of them, of course, is convincing people not to disclaim responsibility to pay. You must have the necessary funds to carry out as quickly as possible some of these programs you have mentioned.

Mr. WARNE. I think problems in the political and sociological arenas are just as difficult as the ones in the technical arena here. How do we get the larger community committed to programs that are essential actually to the life of the whole community, but seems to be restricted to their initial impact?

Mr. DADDARIO. Do you see a growing tendency on the part of the people, however, to recognize the problem and to be willing to support the necessary expenditures?

Mr. WARNE. Yes, I see a tendency, but I wouldn't say that I'm confident at the moment that we can get a drainage district as large as the

San Joaquin Valley adopted, though that certainly is what we believe should be done and it is what we are trying to put forward.

Mr. MOSHER. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Mosher.

Mr. MOSHER. In the last sentence on page 5 of your testimony, you mention the problem of taxes. Would this tax be in the form of a user tax or would it be a conventional real estate tax?

Mr. WARNE. What we actually had in mind and what we have proposed would be an ad valorem tax which would amount to maybe as much as 4 cents on a hundred dollars of valuation, and a user tax or a charge against the discharger who would put water into the drain so that you have two charges really; one on the discharger who would pay on a metered basis for the use of the drain, and the other on the whole community which we believe would pay in accordance with the responsibility that it has for the creation of the drainage problem.

Everybody within the basin contributes to the problem.

Mr. MOSHER. This relates to your earlier testimony in which you referred to the apportionment of costs both to specific and to general beneficiaries.

Mr. WARNE. Yes.

Mr. MOSHER. But, in effect it would be a user tax. You would be paying for the privilege of discharging.

Mr. WARNE. The one who had had immediate access to the drain would pay for the privilege of discharging waste waters into it. I think there is some thought that perhaps the problem is pervasive enough so that part of the cost ought to be carried by the general taxpayer.

Mr. MOSHER. This would be a tax based on real estate values.

Mr. WARNE. Or from whatever the general taxing source was, yes, from the general fund source of the State.

These are problems that have not been resolved. I think at times drainage programs affecting irrigated lands in our State have been delayed until there have been ruinous situations created.

Mr. MOSHER. Basically, these are political problems, aren't they?

Mr. WARNE. Basically they are political problems.

Mr. DADDARIO. You mentioned that part of the problem of drainage waste, was the progressive deterioration of water due to continuous reuse.

Mr. WARNE. Yes.

Mr. DADDARIO. Are we doing enough to forestall this deterioration? Can we build up the reuse cycle over a period of time?

Mr. WARNE. Let me give you an example. I suppose it is the best we have in our State. The example of Santa Ana River Basin in southern California which at its very upstream edge has excellent water. In the head waters of the Bunker Hill Basin in San Bernardino County, the uppermost reach of the Santa Ana River the waters are splendid. We have a situation in the Santa Ana River Basin in which the stream is intermittent, ground waters basins are the real repository of the water supply, and the whole valley has for years depended on pumping water from the ground water basins. There has not been sufficient water in the stream, naturally collected, to supply the needs of the people who live there. So that as the water is

pumped, it is moved progressively downstream and reused for irrigation and other purposes, until down close to the Orange County shore of the Pacific where it becomes pretty heavily loaded with various minerals and depleted to the point actually where the sea water has intruded. You can't tell the difference in some of the wells between the dregs of the lowest basin and the intruding sea. The wells have to be abandoned.

So, what can be done about it: more water can be inserted into the basin and that of higher quality.

In other words, a program can be effected to cut down the recycling effect and to manage the basin so that the new waters are mixed in a way that makes all the waters continuously usable.

We are trying to do this, some of our local agencies in Orange County are doing a very fine job with this kind of program. However, they are using Colorado River water in Orange County at the present time, and it is not of the best quality when it comes from the river. We have a real and continuing problem of managing the waters of the Santa Ana River Basin.

Now, we have thought of, but have not yet put into practice, a means of actually reversing this trend; that would be to desalt, demineralize through one of the desalination processes, a portion of the water, put the utterly unusable brines into the sea, and put the purified water back into use through mixture with the waters that are naturally available in the basin. I think that this kind of program will be practical and will be adopted within another generation.

Mr. DADDARIO. Is there sufficient work going on in this area?

Mr. WARNE. Our State and the Federal Government through the Office of Saline Waters of the Department of the Interior, have undertaken a test center in San Diego County on the San Diego Bay. We had a demonstration desalting plant at Point Loma cooperatively, jointly constructed by the State and Federal Government. We are following this carefully and we are a full participant in it with the Interior Department. They are going to dedicate on the 10th of this month a second plant, the first one having been moved to Guantanamo Bay in Cuba.

Our test center is not completed as yet, but it is underway. We hope to conduct certain experimental work there right along with the Federal Government, looking toward development of practical programs of the sort that I outlined to you a minute ago.

Mr. MOSHER. Mr. Warne, earlier in your testimony you said the reuse of water has become commonplace. However, a number of previous witnesses have implied that it might not be commonplace at all but rather quite exotic. When you say reuse of water has become commonplace, I think you have to make clear that you are talking about it in a very limited sense, aren't you? Aren't there many possible reuses of water which haven't been developed at all?

Mr. WARNE. Well, I will discuss that some, a little later, but I don't think I'm wrong when I say reuse of water is commonplace. In California I am sure that it is. It may not be appreciated or understood or even recognized or admitted, but it is surely happening in the Santa Ana River Basin.

Chairman MILLER. Would the gentleman yield?

Mr. MOSHER. Yes.

Mr. DADDARIO. Mr. Chairman, we are pleased to have you here.

Chairman MILLER. Would you be willing to drink raw Potomac water which had been extracted from above the purification plant?

Mr. MOSHER. Not I.

Chairman MILLER. This water in front of us has been reconstituted. Sometimes we don't appreciate that fact and we get terribly disturbed when we talk about reconstituted water. But most of the water we use has to be filtered and treated with chlorine and then aerated and pumped back to us, and it's good quality water.

Mr. MOSHER. The point I was making, however, was that there are still vast possibilities for the further technology in the recycling and reuse of water.

Mr. WARNE. Oh, I don't doubt that. As a matter of fact, one plant at Whittier Narrows in Los Angeles County of the Los Angeles County Sanitation District presently is reclaiming water out of the trunk sewer; something like 10,000 acre-feet of water a year. The reclaimed water is being put on spreading grounds immediately below the Whittier Narrows Dam where it is percolated into the ground water basin and then is available for reuse by pumpers downstream. Downstream is only a space of a few miles before the Pacific Ocean is reached, but, in this basin reclaimed water is so used.

Now, this has been very carefully planned, very carefully operated, very carefully monitored and we are sure that this water is good when it reaches the ground-water basin.

We are also sure that 190,000 acre-feet additional water could be so reclaimed in the area of Los Angeles by this same process. The additional water is not being so reclaimed at the present time. While we have the technique and the method, we do not as yet have the program to reclaim this large amount of water which is wasted to the sea. That water has a great economic value in our State. It certainly is worth an immense amount of money, and to replace it costs great sums.

Mr. DADDARIO. If you will proceed, Mr. Warne.

Mr. WARNE. One of the most controversial factors influencing the development and utilization of water resources in California is that of nutrients. These are the materials that encourage or stimulate biological growths, particularly algae.

The phenomenon of biological growths in natural waters is a necessary part of the environment. Natural purification provides a tremendous buffer between man's influence and nature's balance.

Algae and plankton constitute a very important fishfood. Without a substantial supply, supported by nutrients, we would have no fisheries.

It is in the area of excessive biological productivity that we encounter undesirable problems such as unsightly growths or blooms where these microscopic plants become so numerous as to become aesthetically objectionable. In addition, upon decomposing, the plant material may actually pollute the water, utilizing excessive amounts of oxygen and often producing obnoxious odors.

There is considerable speculation as to the significance of many materials with regard to the effect on algal growth. It is generally

agreed, however, that nitrogen and phosphorus are perhaps the most significant.

A number of the microscopic plants have the ability to utilize or fix atmospheric nitrogen, making it available to promote algal growth.

Phosphorus, on the other hand, must be added to the water through the natural processes of decomposition of rocks and organic materials or be introduced as a waste pollutant. For this reason, phosphorus is recognized as a key factor in stimulating or limiting biological growth.

In addition to natural sources, phosphorus reaches our water supplies through return flows from agricultural lands and through sewage discharges.

Although phosphorus is an important ingredient in fertilizing materials applied to agricultural lands, return flows do not show significant amounts of phosphorus being returned to our waterways. This probably results from the utilization for crop development as well as from the chemical interaction with the soils which tends to retain the phosphorus.

Municipal wastes, on the other hand, appear to be our most significant source of phosphorus. The major portion of this phosphorus is from the builders used in detergents and other similar cleaning products.

Processes are available for reducing the amount of phosphorus in our waste discharges. These processes currently are being used at Lake Tahoe where nitrogen and phosphorus have been found to pose a threat to the clarity of that unique lake. The phosphorus-removal process is very costly—about $100 per acre foot—for general application. The urgent need to protect the pristine quality of the waters of Lake Tahoe also requires a treatment method to remove nitrates from wastes which might be discharged to these nitrate-sensitive waters. While this is an immediate need, its applicability should extend far beyond this particular instance.

Prolific algal growths have caused problems at Clear Lake and at the Salton Sea. These growths, resulting from excessive nutrients, have contributed to extensive fish kills and to odor problems in the areas where blooms have occurred.

Recognizing that one of the major areas of concern regarding the San Joaquin master drain relates to the possible effects of nutrients on the receiving waters, we are constructing a prepilot treatment plant to study various means to remove or strip nutrients from the drainage waters by inducing the growth of algae and then removing the algae from the water, thereby removing the nutrients that were utilized in the growth. We have submitted an application for a demonstration project grant from the Federal Water Pollution Control Administration to support a portion of our proposed studies.

Another area needing additional study is the development of a method for determining algal growth potential under various conditions. At the present time, we are limited in our capacity to predict with any degree of reliability the extent of algal growth that will occur when waters of differing characters are intermixed, for example, in a combination of sewage effluent and receiving water. We desperately need a tool for determining the possible effects of various stimulants or depressants on the growth of algae which can be related reliably to field conditions.

Mr. VIVIAN. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Vivian.

Mr. VIVIAN. There are three questions I would like to ask on the subject of algae. You mentioned that you expect to induce the growth of algae and then to remove it from the water. I presume this is possible because there is a mechanical process available to do this.

Mr. WARNE. Yes.

Mr. VIVIAN. You can assimilate the materials into organic material which then can be filtered out?

Mr. WARNE. That's what we were thinking of doing in this pilot plant operation to discover whether in this manner we could reduce the dangers of introducing an excessive amount of nutrients from the San Joaquin drain into the estuaries of the San Francisco Bay.

Mr. VIVIAN. Has this process been used elsewhere?

Mr. WARNE. Yes; it has been but I think on an inadequate basis for the demonstration we need here.

Mr. VIVIAN. Are there large portions of the oceans which contain extensive weed area? Is this in any way related to the problem in the San Francisco area?

Mr. WARNE. I'm sure that they do utilize the nutrients in the sea. I haven't thought of them as being on a par with this particular problem, but the sea is a big place.

Mr. VIVIAN. Is there any likelihood that similar sea grasses or kelp could be utilized for removing various types of pollutants?

Mr. WARNE. It is conceivable, but by the time you get the mixture in the sea itself, I think probably the problem is beyond our management. Our fear is introducing these relatively large quantities of nutrients into shallow or confined waters where they peak rather rapidly.

Mr. VIVIAN. For example, between San Francisco and Sacramento Bay?

Mr. WARNE. Yes; or in the San Francisco Bay itself.

Chairman MILLER. I believe that there is a difference between the sea grasses or seaweeds and algae?

Mr. WARNE. Yes, there is, though they are types of algae growth.

Chairman MILLER. Seaweed is found on every coast throughout the world. In California, the collection and production of algae is an important industry. For instance, algae is used as the fixation in cake icings to keep them from running, and is a very valuable product. The Japanese have long used sea algae as a food substance.

Mr. WARNE. Well, actually, there's a possibility of using algae for stock feed and other feeds.

Mr. VIVIAN. Are there growth processes such as with seaweeds which can be used in addition to the growth of algae to remove nutrients?

Mr. WARNE. Well, we suspect that the algae would be the quickest one since it tends to peak first in the receiving waters. I think the others do use the same nutrients, as a matter of fact, but these big seaweeds are much slower growing.

Chairman MILLER. Incidentally, the seaweeds are very high in iodine and certain other elements. During the war the Japanese taught their people who lived on the isolated islands how to supplement their diets by using algae.

Mr. DADDARIO. Mr. Mosher?

Mr. MOSHER. I assume the gentleman from Michigan is wondering whether there is any feasibility in this method for our own Great Lakes area.

Mr. VIVIAN. Yes. I am trying to ascertain if we should start planting certain weed growths.

Mr. WARNE. I don't know enough about your particular problems in the Great Lakes to be certain, though, I suspect that this general line of inquiry might have some applicability.

Mr. VIVIAN. You indicate that you are constructing a prepilot treatment plant. I presume you mean the State of California.

Mr. WARNE. Yes, the State.

Mr. VIVIAN. Have you asked for funds from the Federal Water Pollution Control Administration? What is the general cost of this program?

Mr. WARNE. It is in the low hundreds of thousands of dollars to conduct this program. We spend $300,000 or $400,000 a year on problems of this sort in the State related to the Suisun Bay and estuary.

Mr. VIVIAN. I gather from your comments you have not yet received a grant in response to your request.

Mr. WARNE. No.

Mr. VIVIAN. While I am from a distant State, I would be happy to support your request.

Mr. WARNE. Thank you.

Mr. VIVIAN. At the same time you refer to the need for additional studies to determine the method of algae growth. What is the general cost and who is expected to support this kind of research?

Mr. WARNE. Well, I thought I would leave that question with this committee.

Mr. VIVIAN. I presume our staff will come to some conclusion on it.

Mr. WARNE. We are interested in this in the State, but I think some of the research that is involved here has a far more general applicability than simply to our California problem, and I have raised here several questions as we go through that it would seem to me might be of interest to this committee to pursue somewhat further.

Chairman MILLER. Mr. Chairman, I apologize to my old friend Mr. Warne for not being here when the committee opened. I was in a conference and couldn't get away, and I wanted to come here and pay my respects to him. We have long been fellow workers in the vineyard. When I first came to Congress, Mr. Warne was Assistant Director of the Bureau of Reclamation and then he became the Assistant Secretary of the Interior. Later he went to Turkey to handle our important point 4 program and then to Korea where he did an outstanding job right after the Korean war. In 1961, the Governor of California invited him back to California to head our water resources department, and I'm happy to be here to say hello.

Mr. WARNE. I might note, Mr. Chairman, that in my first assignment back in California after the Governor invited me home from Korea, I was actually a successor to George Miller, though he preceded me by a good many years in that particular assignment. I was a director of our department of fish and game for a short time and your chairman won part of his fame in California in directing the fish

and game commission. We have a very good, we believe, fish and game program out there, and much of it is inherited directly from his effort. Chairman Miller has been a student of our water problems and a supporter of our water projects. Governor Brown and I have many times called on his willing and effective interest. We are made repeatedly grateful to him.

Chairman MILLER. You are very generous.

Mr. DADDARIO. Have you heard from the Department of the Interior during these last few weeks of a new process that they have developed for altering the operation of ordinary treatment plants to improve the removal of phosphates?

Mr. WARNE. I have heard of it, but not in detail. I hope to perhaps get over there and talk to some of them today or tomorrow.

Mr. DADDARIO. So, even though it has been announced, you have not been given sufficient information enabling you to tell us how it might apply to any of the work with which you are concerned such as the algal growth in lakes such as Tahoe?

Mr. WARNE. Not as yet, but we are much interested in it, and we hope to be able to cooperate with them in any demonstration of its effectiveness.

Much has been written and said about the hazards of the so-called persistent pesticides. Actually, many aspects of the pesticide picture are at best only partly known and even less understood.

In the first place, there does not seem to be a common understanding as to the meaning of the term "pesticides." In California we use the definition of our State department of agriculture which defines pesticides as—

> Substances or mixtures of substances intended to be used for controlling, preventing, destroying, repelling, or mitigating any pest. The term is not limited to materials highly toxic to human beings or livestock which are thought of as poisons, but includes insecticides, fungicides, rodenticides, herbicides, vermicides, defoliants, wood preservatives, preharvest dessicants, repellents, antifouling paints, and mildew-controlling paints, as well as substances for control of snails, predatory animals, injurious birds, bacteria, algae, soil infecting nematodes, and other undesirable forms of plant and animal life.

Under such a broad definition, substances such as salt, tetraborates, hypochlorites, and sulfur are placed in the same category as the highly toxic arsenicals, strychnines, and synthetic organic insecticides.

California is a major user of pesticides——

Mr. DADDARIO. Do you mean that the definition is too broad?

Mr. WARNE. I mean that at least people sometimes confuse the terms. I am not in any way underrating the problem of pesticides, but I am saying the consideration of sulfur in the same category as strychnine under a banner of pesticides may cause more alarm than is warranted. We are a major user of pesticides in California, and it has been estimated that we use about one-fifth of the total amount of pesticides used in the United States.

And, I would say that the use of these materials, these agricultural chemicals, is a major contributing factor to the high productivity on a per acre basis of our agriculture out there.

Rather than being apprehensive about pesticides, at least as they are defined in California, I believe that our major concern is really about the poisons and insecticides such as DDT, DDE, endrin, dieldrin, malathion, and so forth.

There are several variables and complexities which complicate evaluation of the pesticide and insecticide situation. First, the pesticides and insecticides themselves are highly variable. Next, collection of a truly representative sample poses a particular and peculiar series of interrelated problems. Finally, analytical techniques are exceedingly complex and still in the development stage.

Commercially prepared pesticides and insecticides frequently are made from byproducts of other industrial activities, and, as such, their composition has a tendency to vary with other portions of the overall production activity.

Many of the more widely used insecticides are insoluble or only slightly soluble in water, so they usually are mixed or diluted with organic solvents or other petroleum or coal tar derivatives prior to field use, or they are applied as dusts mixed with inert materials.

Thus, there is a definite possibility that a significant percentage of a particular insecticide applied to an area literally could be floated away as a scum or oil slick.

Again, when such an insecticide enters a waterway such as a canal, drain, or river, it could remain as a surface scum, or as a result of turbulence and other motion it could become suspended throughout the entire cross section.

A further complication is that many of the organic insecticides are heavier than water and have a tendency to settle to the bottom and intermingle with bottom sediments.

The aforementioned variables make it exceedingly difficult to determine the true significance of insecticide measurements reported from the laboratory.

Additionally, problems which must be met within the laboratory itself provide further reasons to view insecticide measurements with extreme caution. There are numerous pitfalls in the complex analytical procedures. As time passes, however, we are making progress in developing more reliable methods.

One of the most perplexing difficulties, however, is that insecticide solutions of standard strength or of known purity and composition are difficult, if not impossible, to obtain for use in calibrating the measuring instruments. A part of this difficulty can be related to the chemical complexity and to variations in manufacture and in raw materials used to make various insecticides marketed under the same product name.

The complexities of interpreting pesticide analyses are underscored by the fact that the Advisory Committee of the U.S. Public Health Service, in establishing the 1962 drinking water standards, included the following statement in their report:

> Consideration was given to the more common chlorinated hydrocarbon and organophosphate insecticides, but the information available was not sufficient to establish specific limits for these chemicals.

In commenting on the decision to set aside adoption of pesticide concentration limits for drinking water, experts cited two basic reasons: first, the difficulties in establishing acceptable concentrations; and second, the lack of simple analytical techniques for identifying and measuring concentrations of these chemicals.

Although several years have elapsed since establishment of the 1962 drinking water standards, and although much progress has been made

since that time, we still need a simple analytical technique for measuring insecticides.

Another factor worthy of additional study is the method of transport of insecticides from the time of their application, either through the soil or across the lands, until they rejoin our water supplies.

Many of the presently used insecticide materials are "refractory"; that is, they resist degradation with time and exposure to the elements. We need to develop effective insecticides which will degrade rapidly following use.

Mr. VIVIAN. Mr. Chairman?

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. Who is doing the development that you refer to in the last paragraph? Where is the money being spent for developing less refractory insecticides?

Mr. WARNE. Well, I can't tell you of planned programs along this line at the present time.

Mr. VIVIAN. Suppose a commercial firm decided to invest some money in researching with degradable insecticides. Would they have any motive to do so?

Mr. WARNE. Well, I don't know for certain that they would have a motive. I mean, if they could do it cheaper they would have a motive, but in likelihood, they couldn't do it cheaper.

Mr. VIVIAN. Suppose for example, we were to impose an excise tax on nondegradable refractory insecticides?

Mr. WARNE. We think that would be practical only if you had biodegradable insecticides.

Mr. VIVIAN. But, we won't have any biodegradable insecticides until somebody puts some money into research.

Mr. WARNE. You have a vicious circle there.

Mr. VIVIAN. It seems to me that is a very clear-cut chain which is unpleasant to the users, I'm sure.

Mr. WARNE. I think you have some resistance.

Mr. VIVIAN. We have resistance on all matters in the Congress.

Mr. DADDARIO. Mr. Warne, you mentioned that the transportation of insecticides was worthy of study. Could you expand on that?

Mr. WARNE. We find for example, traces of insecticides in places that we can't explain how they got there.

Mr. DADDARIO. My question goes beyond that. Would you add as another factor the study of effects of insecticides on the human beings?

Mr. WARNE. Yes, I think that not only on the human being, but on——

Mr. DADDARIO. Animals?

Mr. WARNE. On fishes and wildlife, domestic animals as well, we need this information.

Chairman MILLER. I think it is well recognized, isn't it, that some of the insecticides used in the Mississippi Valley, and which end up in the river are having an adverse effect upon fish life, particularly on shrimp in the Gulf of Mexico.

Mr. WARNE. There's no question. We know for certain that at certain levels of concentration these insecticides will kill. They will kill fish. They will kill birds, and in all likelihood they will kill people.

Chairman MILLER. Mr. Vivian, Michigan State University conducted some studies some time ago on the effect of insecticides upon robins. Are you familiar with that?

Mr. VIVIAN. Yes.

Mr. WARNE. We have fish kills in California almost every year where, oh, for example, the waters from riceland is permitted to enter a stream without proper dilution. This kind of thing, and also the tendency for the food chain in the waters to concentrate the poisons so that while they might be present in quantities that can't be detected or can just be barely detected, through the food chain they are concentrated to the point where they appear, from time to time, in some of the fishes in pretty high concentrations. We found this to be true. We need to know more about this. We need to know how to control it.

Chairman MILLER. Some of these poisons particularly affect shellfish more than any other fish.

Mr. WARNE. They will concentrate in the powers of 10's.

Mr. VIVIAN. Mr. Chairman, we no longer have any serious problem with insecticides poisoning certain fish in the Great Lakes because all the fish of that type are already dead.

Mr. WARNE. They have already poisoned them.

Well, we have our problems in California, but sometimes I am happy that I don't have to worry about it in the same degree of responsibility of the problems in Lake Erie, for example. But, we are trying our best to handle our situation out there in the estuaries and basin lakes in a a way that will keep them from becoming stagnant wastes, and it is a difficult problem.

During the past several years much publicity has been given to the detergent dilemma. Several years ago detergent foam was a common sight on streams receiving municipal wastes. This foam was related to the ABS used as the active ingredient in the detergent products of that time.

In a massive, voluntary effort, the major manufacturers of soaps and detergents developed a replacement product—a so-called biodegradable detergent—which is known as LAS, which is substantially eliminated in sewage treatment plants, particularly those utilizing the activated sludge process for secondary treatment. Studies show, however, that only about a quarter to a third of the Nation's sewage wastes have this degree of treatment.

Since the changeover to LAS, the technical journals have been filled with claims and counterclaims regarding the biodegradability of the new detergents. The manufacturers of the present products insist that they have solved the problem. Their competitors contend not so and claim that a more degradable product, usually, coincidentally, of a type they manufacture, will be needed as population increases and related waste loadings continue to increase.

To determine progress in changing over from the old ABS to the new LAS, it is necessary for us to measure the amount present in our water supplies and the relative proportions or the ratio between the old and new products. As with insecticides, sampling and measurement is a series of involved procedures, the last of which requires the use of a $15,000 infrared spectrophotometer for measuring the LAS/ABS ratio. Here again the problem of calibration standards

arises because of product variability. Each major manufacturer feels he must have something different to offer. Thus, there is now no single standard against which measurements can be calibrated, so some type of compromise must be adopted.

We need a standard detergent so that all organizations can measure and compare results on the same yardstick.

We also need methods to make rapid and inexpensive differentiation between the old and the new detergents.

Mr. VIVIAN. Mr. Chairman, who is carrying on the research to do those things which you mentioned in these last three paragraphs?

Mr. WARNE. Well, I think the Federal Government is doing some work on it. We are doing a little in our State. The industry is certainly still continuing its efforts.

Mr. VIVIAN. Thank you.

Mr. WARNE. As I have indicated earlier, we in California already recognize that we must reuse our waters if we are to meet the continually growing demand. At this point, I am not suggesting that reclaimed waters should be used directly for domestic consumption purposes, but there are many purposes for which such waters can be used. For example, effluents from municipal waste treatment plants already serve as supplemental water supplies for irrigation of certain crops as well as for parks and golf courses, for development of recreational lakes, for industrial coding water, and for replenishment of ground water basins.

I am proud to note that California is far in the forefront when it comes to conserving our water resources, including the reclaiming of waste waters for reuse. A side benefit from reclamation that is becoming increasingly apparent is that the treatment of wastes to meet quality requirements for reuse often eliminates or substantially reduces the pollution burden which otherwise would be placed on other adjoining water bodies.

Some of the outstanding examples of waste water reclamation and reuse in California are at Santee, which is in San Diego County, at Whittier Narrows, in Los Angeles County, and at Fontana, in San Bernardino County—all in southern California where water supplies are sparse.

The Santee project in San Diego County involves the reuse of highly treated domestic wastes which have percolated through the ground to supply water for recreational lakes used for picnicking, fishing, and boating, for irrigation of a nearby golf course, and for swimming. During a recent 12-month period, nearly 75,000 persons enjoyed the recreational opportunities at the Santee project, none of which would have been possible without water reclamation.

The Whittier Narrows project involves the use of highly treated domestic wastes to replenish underground basins in the county. This plant currently is reclaiming from 10 to 15 million gallons of water per day with a relatively low mineral content which has been discharged to spreading basins for replenishment of the underground supply.

At the Fontana plant of Kaiser Steel in San Bernardino County water is used over and over again until finally the last process is quenching of slag and there is no water left. They literally use even the squeal, as we used to hear about meatpacking plants.

Varying uses, of course, have varying quality requirements. Of those projects just mentioned, for example, each would have a different criterion or quality standard to be concerned about. At Santee the content of bacteria and viruses is important, while mineral content is of little concern beyond the requirements for irrigation.

At Whittier Narrows the main interest is in maintaining a low mineral content. Here the bacterial content is not too important because the reclaimed water must filter down through many feet of unsaturated soils where natural processes remove or destroy such organism.

At Fontana the only criterion for quenching slag is that the water be wet.

Recognizing the broad spectrum of quality requirements for the numerous and varied uses involved, we are now studying the possible application of systems analysis techniques developed by the areospace industry to help us analyze the demands for water and determine the quality necessary for those uses. An analysis of this kind will permit placing into categories those uses having various levels of quality requirements. It will show how much of this water could come from surface supplies, how much from ground water sources, how much reclaimed waste water, what treatment is necessary to meet the various water quality needs for the anticipated uses, and how much it will cost.

Mr. DADDARIO. I think it is a commendable thing that Governor Brown has issued contract awards in the systems analysis area. Do the leaders in the aerospace industry know enough about the water problem to apply the systems analysis approach or will it be necessary for those people, such as yourself, who are the authorities in pollution control to learn this approach?

Mr. WARNE. Well, maybe both. Maybe we both have something to learn but I will say this: In several instances, in relation to the State water project for example, in which I am continuously engaged, we have used the techniques of the aerospace industry through North American, for example, and systems analysis of problems such as the transportation of water in a long canal, and we believe that they have something to offer us.

We have given great study to Aerojet's waste disposal program suggestion. My department, experts in our department are working in connection with this, and while I think the Aerojet people did suffer some from lack of familiarity with the practical problems of water management, or drainage, many of their suggestions are going to prove very useful.

We have committees in the State now from the action departments working on programs that grow directly out of these studies and I think they are going to result in major advances. We hope so. Perhaps both in techniques and in organization.

Mr. VIVIAN. Having worked in systems engineering for many years, Mr. Warne, I am specifically interested to know what particular talents or attributes engineers in the aerospace industry contribute to the water pollution problem?

Mr. WARNE. To the water pollution problem?

Mr. VIVIAN. As to the overall water management problem?

Mr. WARNE. They bring techniques by which we can establish improvements on our models of percolation of ground waters for one.

They bring techniques that assist us in computerizing our control facilities in the aqueduct. We are trying to maintain this aqueduct in a unique manner. For example, endeavoring to keep it ever full because otherwise it might require a 3-week delay to get water from this intake to the point where it is needed. We need this aqueduct operating on a split second basis. Just as though the water were within a pipe.

This is theoretically possible but it hasn't been practically possible heretofore owing to the length of time required for communication and for sending a man out to refix the headgate, and this kind of thing.

We are using the techniques of systems management in setting up a program here in combination with experienced engineers and business administration people that we think is going to make it possible to readjust gates instantly and keep the aqueduct full and at the same time prepare the bills for the water users so that it all comes out of the same operation.

Mr. VIVIAN. Have your water reclamation people, who have been in business for years, found systems engineers of great assistance?

Mr. WARNE. I can't answer that. I think we are just now getting into areas where we believe they are going to be of great value to us. I mean, the most complex water program we have is the one I have just described to you. I know the metropolitan water district is thinking along some of these same lines.

They are perhaps the next most complicated water operation in the State.

Mr. VIVIAN. The nature of my question is simply that there has been much opposition to the use of systems engineering for pollution abatement. I have no objection to it, but it is not altogether obvious that the clear-cut areas of value have been established.

Mr. WARNE. We think that the kinds of controls that are going to be necessary in the future at least, to maintain acceptable water quality standards in the San Francisco Bay are apt to involve this kind of thing.

Mr. VIVIAN. Thank you.

Mr. WARNE. There are a number of other apparent possibilities for use of waste water that, to my knowledge, have not been exploited to date. These include irrigation of shrubs and plants used for landscaping freeways, washing gravel, compacting soils in construction projects, replenishing of underground strata from which oil has been removed, as well as secondary recovery of oil. The use of such supplies is already feasible, particularly in water-deficient areas.

There is one area where technical knowledge is less advanced than is desirable, and this is in the understanding of disease-producing organisms in water. For years water supply engineers judged the effectiveness of their treatment processes by studying changes in the density of coliform organisms. The presence of certain strains of these organisms can be related to such waterborne diseases as typhoid, dysentery, and other intestinal disorders.

In more recent years we have learned that viruses are responsible for polio and hepatitis. To date, although we can identify a number of major groups of viruses, there are no generally applicable methods which can be utilized in routine pollution studies.

"Desalination" is a term which has been coined to encompass all of the methods and techniques available for removing and reducing the amount of salts dissolved in water. The term includes those processes for sea water conversion as well as those intended to reduce the salinity of brackish waters.

We are extremely interested in desalination. California participated with the Office of Saline Water in the construction of a saline water conversion plant at Point Loma. We are again participating with the OSW in its San Diego Saline Water Test Facility. The plant will be constructed by the OSW, and the State will market the water.

If financially feasible processes were available, we could use them to provide supplemental water to Los Angeles and other south-coastal metropolitan areas. Economical processes could reduce or perhaps even eliminate the problems of increasing salinity in the Salton Sea which now threatens to become too salty for the ocean fishes that abound there at the present time.

We also might be able to use these processes to remove the salts from drainage waters in the San Joaquin Valley, thus adding to our water supply as well as decreasing the problem of drainage removal.

Although numerous desalination methods are available, none of them are economical enough for general use at this time. Limitations of time and cost have forced us to proceed along more conventional lines in coming to grips with our immediate problems.

In one San Joaquin Valley town, Coalinga, both electrodialysis and reverse osmosis processes are being used to demineralize brackish well waters to provide drinking water for the community. These processes, though costing about $100 to $150 per acre-foot, provide substantial savings when compared to the cost of the former method which involved the transportation of drinking water to the community in railroad tank cars. Here again the use of available technology is limited by the costs involved.

Cost, however, is not the only problem. There are other water quality factors which must be resolved in addition to breaking the cost barrier, a major one being what to do with the concentrated wastes. When desalination plants are located inland, the problem is to get rid of the concentrates without permitting them to reenter the water supply.

The problem of brine disposal is also present when desalination plants are located along the coastline. There is insufficient knowledge of the ecology and currents in the ocean. For instance, it is believed that sections of the offshore waters are almost devoid of plant and animal life in contrast to their great abundance elsewhere. There has never been a comprehensive survey of the coastal ecology and the horizontal and/or vertical currents. In order to provide a safe place in the ocean for deposit of hot concentrated brines, comprehensive surveys of the ecology and oceanography of the most likely section of the coast should be made.

Mr. VIVIAN. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Vivian?

Mr. VIVIAN. You have touched upon a subject of very great interest to me; of the ability of the ocean to absorb types of waste over long

periods of time. I would anticipate that the New York City area is surely going to have troubles. I have no idea how soon and what types of trouble. The total volume of materials flowing out of New York as you know, is awe-inspiring. I gather you have some studies of the ecology of the Pacific Ocean along the coast of California.

Mr. WARNE. We have limited studies but they are not nearly extensive enough and I doubt if they are going to get us enough answers in time. I think we need an additional concentration of this kind of effort.

Mr. VIVIAN. Is any of this work being conducted with California funds?

Mr. WARNE. Yes, some through the University of California, the Oceanography Institute at La Jolla, and through our department of fish and game. We are doing some of this, and we are presently planning additional programs which we hope to bring forward in the next session of the legislature.

Chairman MILLER. The ocean is a very big place and people feel that you can dump anything into it. But I think we have learned that this is a fallacy. Back about 1948, you might remember we had some pretty lean water years in California. One chemical plant that produced chlorine did so by using the dump power that was generated under normal conditions. Since this surplus power was not present, they couldn't supply the chlorine that the city of Los Angeles needed to sterilize its sewage. This resulted in southern California beaches being posted and no swimming was allowed because of the contamination.

Then again, sharks have appeared in waters off southern California where they never previously appeared, and the studies made indicated that the slight rise in temperature through the disposal of sewage changed the ecology and caused the water to become suitable for the sharks to exist. These are the things that we don't know very much about. We have just begun to scratch the surface in this field. Some years ago when the Atomic Energy Commission issued a report on the disposal of atomic waste along the Atlantic and gulf coasts, the Subcommittee on Oceanography, which I then had the privilege to head, made some studies and wanted to publish a study of the disposal of these wastes on the Pacific coast. When the Atomic Energy Commission was alerted, no such report was ever rendered. Is that correct?

Mr. WARNE. I don't think so.

Chairman MILLER. As I understand it, the people, in the three west coast States wanted to deposit the atomic waste in the ocean. It just didn't work out even though this was to be a very slight concentration. They were supposed to dump the waste in a thousand fathoms of water. The material was deposited in steel drums covered with concrete and was supposed to sink to the bottom of the ocean. The division of fish and game in California duplicated these drums, sunk them, and found that they were floating at 400 fathoms rather than a thousand.

Off the shore of New Jersey two of these drums had been supposedly dumped in a thousand fathoms of water, but became snagged in the nets of some fishermen. This was very low level waste and I presume did no damage, but what will happen if there is a high level of damage?

In England they pump waste into the North Sea, which affects the fisheries on the Grand Banks. The Japanese, hired the Pritchard Bros. to make some studies for them. They found upwellings of water where they didn't expect them. They completely disassociated themselves from it and will not allow the deposits of wastes.

At this time no one knows how much of the ocean is contaminated, but there is an indication that a great deal of work has to be done in this field.

Mr. WARNE. The ocean certainly requires additional study.

Mr. VIVIAN. Are there any Federal control water pollution laboratories in California?

Mr. WARNE. No.

Mr. VIVIAN. None as of yet. I thought there was one.

Mr. WARNE. We would like to have one there.

Mr. VIVIAN. To the best of my knowledge there is an existing program for the construction of Federal water pollution laboratories in several areas of the country.

Mr. WARNE. Yes.

Mr. VIVIAN. We are anticipating the construction of one very shortly in my own home city. It seems one of these laboratories would be concerned with the problems of the ocean.

Mr. WARNE. We have thought that one oriented to the ocean and the coastal areas of our southern California would be a very valuable adjunct to the present program of the water pollution agency. There's one at Ada, Okla. There is one at Corvallis, Oreg. There is none in California.

Gravel quarries and borrow pits from which fill materials have been excavated can be used for disposal of certain types of solid wastes. When filled, these areas can be placed back into desirable use for golf courses, parks, and similar types of development. The effect of filling these quarries with decomposable materials, however, has given us some cause for alarm. We already have encountered ground water pollution problems resulting from the downward movement of gases from decomposing materials deposited in alluvial areas and the adsorption of these gases into the underground water. These are in addition to the usual problems of differential settlement, gas, and odors associated with operations of this type.

Problems of solid-waste disposal have become of great concern in California where much of our population virtually lives on the leaky roof of its own water supply. Several years ago, at the request of Gov. Edmund G. Brown, representatives of the aerospace industry were called upon to make a study and to report upon the problems of solid-waste disposal in California.

The Governor recently appointed an interdepartmental task force on waste management to consider the recommendations made in the aerospace report, and to develop a long-range plan for solid-waste management. The committee is now considering the various alternatives and is scheduled to report to the Governor in the near future.

I suggest that your committee might find the problems of solid-waste disposal a fruitful area for further study.

And, in summary, during this, the first part of my presentation, I have brought to your attention a number of areas where we need more

knowledge of factors affecting our environment, where we need better methods for measuring these factors, and where other technological breakthroughs are needed.

Although we have come a long way in pollution abatement, more effective water resources management can be achieved by giving attention to these troublesome areas.

I suggest that this committee might assist in providing for increased scientific effort directed toward the development of—

1. Generally acceptable parameters to measure and define baseline conditions in order properly to assess costs and benefits of changes in environments;

2. Economical processes for removing nutrients from waste water;

3. Methods for determining algal growth potential;

4. Simple and less costly methods to measure insecticide concentrations in the environment;

5. A better understanding of the movement of insecticides after they have been applied;

6. Effective insecticides which degrade rapidly after use;

7. A detergent standard against which measurements can be calibrated;

8. Methods for measuring and interpreting the significance of viruses occurring in water;

9. Methods of assessing and effects of the discharge of concentrates from sea-water conversion and other desalination plants; and

10. Better methods for the disposal of solid wastes.

Mr. VIVIAN. Mr. Chairman?

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. I am very pleased to have Mr. Warne set forth this list of 10 items, all of which appear to me to be very reasonable and all of which will be of great assistance to this committee.

Mr. WARNE. Thank you.

Now, I have a little more material on questions that the committee asked.

The second part includes specific answers to the administrative and policy problems listed in part E, section VI, of the Report of the Research Management Advisory Panel.

The questions raised by the Panel probe areas of concern to all who must wisely manage our resources. There are no single answers, but experience we have gained in pollution abatement in California provides a basis upon which we can take a considered point of view.

The first question was: *What should be done to define State and local responsibilities in applying technology?*

In California the responsibility for water quality control is assigned to nine regional boards, generally one for each of the major drainage basins of the State. These regional boards are, in turn, responsible administratively to the State water quality control board.

Until very recently the regional boards were responsible only for the control of pollution, per se. The boards did a good job of regulating municipal and industrial waste discharges, to which their responsibilities were limited. During 1965, however, the legislature changed them to water quality control boards and assigned them

broad powers to control any factor which adversely and unreasonably impairs the quality of the waters of the State for beneficial use.

Water quality control agencies are rather gingerly approaching their new assignment. For the most part, they have little experience with water supply and in water resources development.

The boards to date have failed to recognize that water quality and water quantity cannot be viewed as separate avenues but instead constitute closely interrelated segments of water resources development. The problem of water quality can no more be solved without reference to other aspects of water resources development than can the problems of water supply be met without reference to quality.

Recommendations have been made regarding the reorganization of the State government by the so-called Little Hoover Commission which would help to eliminate this increasing dichotomy with regard to water in California. The commission's recommendations with regard to water quality control on a statewide basis were as follows:

> The dangers of the existing organizational separation of water quality control from the other water programs of the State are becoming more apparent with the implementation of the Water Plan. The existence of one central and nine regional bodies, each with its own staff and with standard-setting and decision-making authority in the quality of coordinated action. The problem has reached critical proportions, particularly in the San Francisco Bay and Delta areas.
>
> It is recommended that the State Water Quality Control Board be merged with the California Water Commission.
>
> Water quality standards would be set, statewide and by river basin, by the Department of Water Resources subject to review by the Water Commission, which would hold needed public hearings in connection therewith. The Commission would assume the Water Quality Board's role in the approval of loans and grants for local projects and for research.

At the Federal level we see already much of what the Little Hoover Commission proposed be done in California with comparable State functions and agencies.

In California we will need to work diligently to avoid granting independent power over quality maintenance on a regional basis to one group of boards and separate power over quality maintenance on a statewide basis to a different board.

How can the training and equipping of local officials be coordinated with industrial pollution control personnel?

As a part of the present procedures for establishing waste discharge requirements as provided for in the California Water Quality Control Act of 1965, it is necessary for pollution control officials to meet and work closely with local officials so that they can understand the meaning of the requirements prior to their adoption by the control board involved.

During the course of these meetings any needs for training or equipping local officials can be brought forward and appropriate measures taken to remedy them.

In addition, local professional groups, mainly the California Water Pollution Control Federation, provide short courses, technical meetings, and group seminars to provide training and exchange ideas in technical matters.

This approach seems to work fairly well in the populous areas but needs improvement so far as the more remote or less populous areas are concerned.

The second question raised in the report of the Research Management Advisory Panel was, *How should the evaluation of pollution situations be divided between local and Federal technical groups?*

The evaluation of pollution situations requires the efforts of both Federal and State agencies. The States should take responsibility to make the initial evaluations.

When interstate waters are involved, both Federal and State technical groups should be encouraged through informal conferences to exchange viewpoints and to reexamine the available technical information. We have some reservations about conducting discussions of a technical nature in the public arena where differing procedures and objectives tend to polarize affected interests to the point that mutual evaluation of the problems becomes difficult.

The States must increase their efforts at pollution abatement through more comprehensive investigations and analysis. In this way, local interests and needs can be placed alongside the national interests.

We believe the division of responsibility for evaluation of pollution situations warrants close attention in the coming months.

Mr. DADDARIO. On this question of your reservations on conducting discussions of a technical nature in a public arena, do you believe that there are other ways in which we can get this information without having people assume positions only because they state them in public and then solidify forces behind those positions?

Mr. WARNE. I believe there is a possibility, at least, that there is in our State, of making a considerable amount of progress through less formal, more informal discussions. Perhaps then followed by public hearing at which everybody can speak his piece. I think the danger in polarizing a State position as opposed to a Federal position would be lessened if we did this; or of polarizing a local position as differentiated from an interstate position. I think we are all learning and I hope that we can make additional progress here.

Mr. DADDARIO. I don't raise the question because I believe that everything originates with an open discussion.

Mr. WARNE. Well, certainly——

Mr. DADDARIO. I do have the feeling that, in problems of this kind, where there is so much need to get people together who have technical and a scientific competence, a great deal of preliminary work ought to be done before you reach the stage of presenting the problem to an open committee.

Mr. WARNE. Well, I think so, too. I think perhaps more general advance might be achieved that way. I'm strong for the educational effect of the public meeting and hearing and also for the educational effect on both State and Federal agencies of having some representatives of the public come in and express their views. I think this is essential, but, what we ought to aim at is to get a good result and I would hope that we could find ways of expressing all of these needs and getting a better result.

Is area industrial development distorted by a preference for clean industries over presently known or potentially polluting industries?

Application of the present procedures for establishing waste discharge requirements can and has affected industrial development in certain parts of California through adoption of restrictive standards.

The effects, for the most part, have been to delay rather than forestall such development. For example, about 10 years ago a large paper concern had developed preliminary plans to construct a papermill on the upper reach of the Sacramento River but abandoned its plans when the cost of providing the degree of waste treatment to meet quality limits was recognized by itself. Today a papermill operated by a different concern is situated quite near the exact site originally proposed. The present plant, however, utilizes a different type of process than that originally proposed, one which produces a lesser amount of waste and wastes less costly to treat.

I do not regard the deferment of industrial development as in this case as a distortion of progress, but rather as a necessary action to protect the quality of the environment.

To what extent should zoning or selected industrial location with respect to population be used to decrease the need for effluent treatment?

Procedures for the establishment of waste discharge requirements as provided for in California laws have had the practical effect of creating industrial areas. These procedures require the regional water quality control boards to recognize beneficial uses when establishing quality requirements.

A trend has developed whereby many heavy industries have been pushed to the ocean shores and to the bays and estuaries rather than bear the additional treatment costs usually involved in locating inland. For the most part, however, we find that these industries are willing to pay the necessary costs of treatment in order to locate in proximity to the large population centers with a ready labor potential and reduced transportation costs.

We all must recognize that our waterways have been and will continue to be used to carry away our wastes. There is a necessity, however, to avoid degradation to the detriment of other beneficial uses. To avoid such a consequence, both the Congress and the California Legislature adopted laws in 1965 which require adoption of quality standards, to be maintained at various key points in our waterways, to protect these waters for beneficial use. We are establishing these standards in California.

The next problem we expect to confront will arise when the concentrations in our waterways begin to approach the adopted quality standards, and consideration must be given to upgrading treatment processes to stay within the recognized standard.

We do not believe that dischargers should be permitted to claim a prescriptive right to pollute, but rather that all dischargers should bear a proportionate share of the costs of needed remedial measures.

We are facing these water pollution control problems in the San Francisco Bay area. As waste-producing activities increase, the magnitude of the problems will expand. In recognition of this, the legislature authorized a comprehensive investigation of the effects of waste discharge into the bay with the directive that a plan be developed for the control of pollution. This is chapter 1351 of the Statutes of 1965. An amount of $1,078,000 has been appropriated for the first of a 3-year investigation.

Waste dischargers should not flee from the population centers in order to pollute other waters. Instead, the problems should be faced squarely and efforts made to solve them.

How far should restoration of environmental quality be carried if costs and benefits cannot be appraised in a free market manner, nor most hazards demonstrated to have public health effect?

We do need to consider economic costs of maintaining and, for the most part, restoring environmental quality. There are instances, however, where serious consideration should be given to upgrading environmental quality beyond benefits which can be appraised in a free market. Restoration also may go beyond those standards generally considered adequate to protect the public health. Although it is generally possible to express costs of restoration fairly accurately, it is difficult to convert certain types of benefits to monetary values. Such factors as aesthetics, public health, and other social values must be placed on the scales. Much of the final determination must depend upon present and foreseeable beneficial uses, taking into account the trend for increased leisure time.

Lake Tahoe is an example of a situation which warrants consideration of the type suggested. Renowned for its clarity and beautiful blue hue, this body of water remains as one of the three clearest lakes of the world. Although the major dischargers of domestic sewage within the basin of the lake all provide for treatment of their wastes, one even providing tertiary treatment to reduce phosphate levels, it has been determined that all sewage effluent must be exported from the basin to prevent the lake from turning into a green pool of algae. Here, the need for preservation of a unique natural resource was recognized and has required that monetary costs should not be the determining factor.

What techniques of social science can be used to establish public opinion and public support in pollution abatement?

I do not believe that any new techniques are needed to gain public understanding and support in pollution abatement matters. In California, there is a growing understanding and increased appreciation of the need for a clean environment. The public wants it. What remains to be done is to implement action programs necessary to provide this environment.

Mr. DADDARIO. Do you think the public understands the pollution problem well enough to be willing to pay for it?

Mr. WARNE. I think in some instances they probably do not but I don't think we need any new techniques. If someone came up with a new technique, I would not be adverse to employing it. I don't think the question of public understanding is the main problem that we have in this field today. As a matter of fact, in general, I would say the public has outrun most of its representatives in this desire to see something done about cleaning up the waters and the atmosphere. I don't mean that they, no more than we, always relate their desires to their actions. They might still be opposed to setting up a drainage district. But they are interested in having the drainage function performed.

Chairman MILLER. Mr. Warne, sometimes they see or know or smell the problem, and they become quite vocal. They would treat the symptoms of the disease and not get at the basis of it.

Mr. WARNE. Yes.

Chairman MILLER. The fact is that the people are aware of the problem but we must do more to increase their understanding. One hundred years ago, if you had tried to sell the people of California on spending money they do now in the field of reclamation they would have laughed at you. We have spent a great deal on reclamation, but it has paid off and will continue to pay off. There is a need for more education, and I think this is one of the places where we can be of benefit.

Mr. WARNE. It is possible that our State since it is a semi-arid state, has a higher sensitivity involving water quality than in some other areas of the country.

Mr. DADDARIO. However, there are other aspects of this question which need to be considered. I am not only concerned about whether or not there is public acceptance or public understanding of the problem but also whether there is enough support for the expenditure of funds in certain areas where the technical knowledge is not presently available. We must convince the public that such expenditures are necessary for the development of research techniques so that the job can be accomplished cheaper and more efficiently. This is one of the principal questions in our report. Aren't we, in fact, spending money in certain programs which are not as effective as they might be? Shouldn't we hold off until we develop better techniques to overcome our problems?

Mr. WARNE. I certainly agree with you that we need the improved techniques and we are endeavoring to develop those that seem emergent to us in California and there is a problem of getting them recognized in time. I will give you better examples in some other fields than in waste or pollution control at the moment, but we are presently in several of our rivers building dams that will submerge old dams in their reservoirs by reason of the fact that we didn't have the techniques to understand what the full import of the problem was when the dams were built 30 or 40 years ago. So now we are in effect having to duplicate and waste certain of our earlier efforts. I presume that something like this may happen in the water pollution abatement field, too. So, it is important that we get this public understanding channeled into the field of support, I think, of the research that is necessary. This, I agree with you on. I certainly do.

Mr. DADDARIO. But we must have a better understanding of that which is available to us and is not being adequately utilized at the moment.

Mr. WARNE. Yes, we need—it makes me feel tired sometimes, we need to rework this area almost every month. Our State is growing. New people are coming. They don't bring with them an understanding of the local problem, so it is necessary to educate, reeducate all the time. Not only on an obvious problem like water supply but all the more so on the more intricate problems of water quality.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. On page 28 of your testimony, Mr. Warne, you referred to a papermill which was to be located in the upper region of the Sacramento region but abandoned its plans. I wonder if you could tell me where that paper plant eventually located.

Mr. WARNE. I am not sure that particular one was ever located in California. But another company brought a mill in at this particular site but it was a different mill.

Mr. VIVIAN. I would appreciate it, Mr. Chairman, if we could find out if that company eventually did locate on the ocean.

Mr. WARNE. That particular plant eventually located in Virginia, I believe, but not on the ocean. Another company brought a mill in at a nearby site on the Sacramento River about 10 years later. The mills on our north coast area and the one on the Sacramento River are all pulp or so-called "kraft" mills.

We did eventually have some locate on it, on the ocean at that time, but they have had to boost their waste control standards a good deal even there.

Mr. VIVIAN. Can you tell me why they had to boost their disposal standards when they located on the ocean?

Mr. WARNE. Because the earlier standards seemed to constitute a threat to the ecology of the receiving waters even in the ocean.

Mr. VIVIAN. Are these California plants?

Mr. WARNE. Yes.

Mr. VIVIAN. Could we identify those plants and the criteria used for the disposal of the effluent?

Mr. WARNE. I could. I would be glad to do that for you. The waste discharge requirements governing the plant on the upper Sacramento River at Anderson, Calif., specify quite a few conditions which must not be exceeded in the river. For instance, the waste cannot cause dissolved oxygen to drop by more than a half part per million, and in no case is it to be decreased below a minimum of seven parts per million. There are stringent limits on the various physical and chemical constituents in the waste, on acidity, on temperature, and the disposal must not cause a nuisance due to odors or unsightliness. The plant is required to submit frequent reports of river and waste discharge conditions to the water quality control board. The Sacramento River is a very important salmon and trout spawning area, and the requirements are designed primarily to protect this use.

Plants located in our north coastal area discharge their wastes to the ocean through submerged outfalls. Requirements specify a small zone of dilution around the outfalls in which the wastes are allowed to diffuse. Outside this zone the requirements are designed to protect fish life by the maintenance of adequate dissolved oxygen levels. All other constituents must be maintained below levels which may be harmful to fish. Nuisance conditions are prohibited. Periodic monitoring reports from the plant are required by the regional water quality control board there, also.

In general the requirements for ocean disposal are less stringent than for fresh water disposal, and plants can take advantage of the greater dillution available.

Mr. VIVIAN. On the same page of your testimony, you referred to a different type of process used in the paper plant that was located there. Do you mean different manufacturing process?

Mr. WARNE. A different manufacturing process. The first mill, the one that did not build, would have produced a cellulose product to be used by other plants to produce final paper products. The particular process would have converted about 40 percent of the raw material, logs, into refined cellulose, while the other 60 percent would have been discharged to the river as waste. Some treatment of the

waste was proposed, but it was not sufficient. The second plant, the one that did build, produces finished paper products. The process actually uses about 60 percent of the log and wastes only 40 percent. Also, this 40 percent is much more amenable to treatment than the wastes from the first mill proposed.

Mr. VIVIAN. Which made the disposal of the paper waste more readily possible?

Mr. WARNE. Less difficult.

Mr. VIVIAN. In my district we have a number of paper plants and a very serious problem of pollution. I gather this was a new type of process.

Mr. WARNE. I believe it was entirely new, yes, though it is not new now. It is being used in several places today.

Mr. VIVIAN. On pages 29 and 30 of your testimony, you refer to the same subject again. When you say a trend has developed whereby many heavy industries have been pushed to the ocean shores, bays, and estuaries rather than bear the additional cost of locating inland, can you indicate what types of business these have been?

Mr. WARNE. Refineries, sugar mills, chemical plants, particularly.

Mr. VIVIAN. Congressman Vanik of Ohio, who testified before this committee, proposed that there should be industry-by-industry standards. Each industry, whether it was located in Nebraska or along the Atlantic or Pacific coast, for example, would have to reduce its effluent to acceptable nationwide and industrywide levels. If such standards were established plants could not locate in communities which either had no laws or refused to enforce the laws.

Do you have any personal opinion on this subject?

Mr. WARNE. Well, I would doubt where a national standard as high as those we are imposing would be enforced and I think we might object to it.

Mr. VIVIAN. Why would you object to it?

Mr. WARNE. Because we want the higher standard.

Mr. VIVIAN. Why would you object to a national standard which would be as high as your standards?

Mr. WARNE. Oh, I say, no, I wouldn't object to that necessarily. It might be a feasible solution. It might be. In other words, so that someone wouldn't get an advantage by locating a mill in a place where you could produce it as cheap as possible without regard to consequences, I think in most instances we found that the enforcement of higher standards have not really in the end been an economic deterrent. Lots of times, it is just an excuse for carelessness and not to have good standards.

Mr. VIVIAN. What procedures do you have available for monitoring the effluent output of plants and municipal treatment systems in California?

Mr. WARNE. These are monitored through the good offices of our nine water quality control boards, regional boards, on a regular basis, I believe every month. In addition, the department of fish and game monitors waters that have importance for fishery—both offshore and inland, and the department of water resources has ground water quality monitoring programs, very extensive throughout the State, and surface water quality monitoring. The programs of the depart-

ment of water resources are not related directly to effluent discharges but rather to general quality trends and programs. Fish and game monitoring programs relate to the welfare of the fishes and the programs of the regional boards relate to the drinking water and receiving waters from health standpoints and other quality requirements.

Mr. VIVIAN. Do you maintain any continuing random time inspection of water quality from, say, individual plants or individual areas?

Mr. WARNE. This is done through the work of the regional boards and the department of health.

Mr. VIVIAN. Do you feel this provides a good assurance the people will not casually turn off their pollution control abatement systems at moments when they don't expect to be inspected?

Mr. WARNE. We have had instances where there have been unexpected fish kills. I would say the department of fish and game probably has had as much success of training them not to turn off their treatment facilities as anybody else. The discharger doesn't like to be hauled into court on that kind of a charge, that he caused fish to die in the waters.

I think we have fairly good cooperation in our State. We do have—we have unregulated releases. Most of these are accidental. Sometimes the facilities that were good last year aren't big enough for this year, whether it be municipal outfall or something else. It is necessary to go through quite a procedure to get additional capacity built into the facilities. At times there is unwarranted pollution while this is in process.

But, I would say that our program has been fairly effective. We are proud of the fact. We also have had cooperation, I think, from the general run of our dischargers.

Mr. VIVIAN. The Federal Government has some very large installations in California. Has the Federal Government been a good cooperator?

Mr. WARNE. There was a time when the Federal Government was not a good cooperator. As a matter of fact, some of our worst situations were caused by some of the Federal installations but I believe this has been corrected now. It is in process of being corrected throughout.

Chairman MILLER. I think it is pretty well corrected now. There were times when they were the biggest offender.

Mr. WARNE. We have had some trouble of ships, including naval ships, dumping stuff in bays, but we are after that, too, now and we are getting the cooperation from the Navy.

Mr. VIVIAN. No further questions.

Mr. DADDARIO. Mr. Chairman?

Chairman MILLER. I am very happy to have you here, Bill, and I want to thank you for coming. I certainly enjoyed seeing you.

Mr. DADDARIO. Mr. Warne, the committee wants to commend you for what is certainly an excellent report. It is obvious that you applied yourself diligently to our inquiries. The manner in which you have answered our questions here today is most exemplary and I know that every member of the committee appreciates it. You have added a great deal to the work that we are doing here.

Mr. WARNE. I want to thank you, Mr. Chairman, very much. I appreciate the opportunity to come.

Mr. DADDARIO. Thank you.

(The biographical statement of William E. Warne follows:)

BIOGRAPHICAL STATEMENT OF WILLIAM E. WARNE

William E. Warne, state, federal and international government official for more than 30 years, is the Director of the California State Department of Water Resources.

His professional career has been concentrated on two resources fields. He has worked for the conservation and development of water and other natural resources in California and throughout the nation. He has directed resources and economic development in foreign countries on behalf of the United Nations and the United States.

The civil service and appointive posts in which he has served since 1935 include the following:

State of California: Director, Department of Water Resources (since January 3, 1961); first Administrator, Resources Agency of California (from beginning of Agency October 1, 1961, until January 6, 1963, while also Director of Water Resources); Director, Department of Agriculture (1960); Director, Department of Fish and Game (1959).

International: Economic Coordinator, United Nations Command, Korea (1956–59); Mission Director, U.S. International Cooperation Administration, Brazil (1955–56), and Iran (1951–55).

Federal: Member, Water Pollution Control Advisory Board (1962–65); Assistant Secretary of the Interior (1947–51); Assistant Commissioner, U.S. Bureau of Reclamation (1943–47); Chief of Staff, War Production Board (early World War II); special assignments to national resources, power and river basin work and information and editorial positions in the Bureau of Reclamation (1935–42).

Warne was raised on a farm in California's Imperial Valley. He was a newspaper and press service reporter and editor in California and Washington, D.C., for eight years after he graduated from the University of California in 1927.

The United Nations, the United States and foreign countries have honored Warne for his work. Special awards to him included: United Nations Command's Citation for Outstanding Service (1959); honorary degrees, Seoul National University and Yonsei University, Korea (1959); U.S. Foreign Operation Administration's Honor Award for Distinguished Public Service (1955); Shah of Iran's Order of the Crown (1955); U.S. Department of the Interior's Distinguished Service Honor Award (1951).

Warne is the author of "Mission for Peace", a book in which he relates his experiences in Iran as the administrator of the United States' first Point 4 Program.

Warne was born September 2, 1905, near Seafield, Indiana, and moved to Imperial Valley with his family in 1914. He graduated from the Holtville (California) Union High School.

He and his wife, the former Edith Peterson of Pasadena, have three children: Jane Warne (Mrs. David C. Beeder of Decatur, Illinois); William Robert Warne, in the U.S. Foreign Service; and Margaret Warne, Cornell University graduate. He lives in Sacramento.

He is a member of Sigma Delta Chi, Lambda Chi Alpha, the National Press Club, Washington, D.C., the Commonwealth Club of California, and Los Angeles Town Hall.

This committee will adjourn until 10 o'clock tomorrow morning at the same place.

(Whereupon, the hearing in the hereinbefore entitled matter was adjourned at 12:10 p.m. to be reconvened at 10 a.m., Thursday, August 4, 1966.)

(Signed) William H. Wayne (follows:)

THE ADEQUACY OF TECHNOLOGY FOR POLLUTION ABATEMENT

THURSDAY, AUGUST 4, 1966

HOUSE OF REPRESENTATIVES,
COMMITTEE OF SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The committee met, pursuant to adjournment, at 10:15 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our first witness this morning is Dr. Walter Hibbard, Director, Bureau of Mines, U.S. Department of the Interior.

Would you come forward, please, Dr. Hibbard?

I would like to have the members of the committee know that Dr. Hibbard and I were classmates at Wesleyan. He is an old friend of mine and I was extremely pleased when he left private industry to come to Government so he could find out what it is to work under these conditions.

I can say that in my conferences with him I have learned that he found it is a much more difficult proposition than he expected.

We welcome you to the Government's work. Please come forward and start your statement.

DR. WALTER R. HIBBARD, JR., DIRECTOR, BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR

Dr. HIBBARD. May I introduce my colleagues?

Mr. Harry Perry, who is the Acting Director of Minerals Research, and Mr. Richard Mote, who is Chief, Office of Program Coordination.

Mr. DADDARIO. We welcome you both.

Dr. HIBBARD. If I may, I would like to summarize the written version of the testimony emphasizing those things which I think are of particular importance.

I am pleased to have the opportunity to appear before you to discuss the technologic problems facing the Nation in its efforts to abate environmental pollution.

The introduction of our testimony summarizes the problem as it exists. I am sure you already know that there are millions of tons of contaminants every year produced from the combustion of fossil fuels, which pollute our atmosphere, streams, and land. The problems of environmental pollution are to a degree a byproduct of our economic success and inasmuch as adequate disposals of waste in general had no eco-

nomic return or incentives, the technology to handle such material has been largely neglected.

I would like to discuss for a few moments the role of the Bureau of Mines in this area because I think it is not as well known as it should be.

The Bureau of Mines, by its organic act, is charged with the responsibility to conduct scientific and technologic investigations in the mining, preparation, treatment, and utilization of minerals and mineral fuels with a view of improving health conditions, increasing safety and efficiency, and conserving our resources through prevention of waste. In accordance with its initial congressional mandate, the Bureau has been engaged for more than 50 years in research investigations designed to conserve our natural resources, and in many studies aimed at minimizing pollution, since pollution from wastes often represents inefficient use of our resources.

In the water area these investigations have included acid mine drainage alleviation through mine sealing, economic means of utilizing or disposing of mine wastes, and prevention of contamination by leaching of mine tailings. And while we have made progress in many of these areas, the problems have expanded much more rapidly than the solutions.

In the field of air pollution abatement the Bureau is concerned with engine exhaust fumes. It has also been active in research on the utilization of mineral fuels and in general with the minimization of pollution. Here again, our research has not been able to keep pace with the growth of the problem.

The Bureau has had a longstanding interest in the reduction of sulfur oxides pollution resulting from the combustion of fossil fuels and from metallurgical operations. In these areas we have worked on the cleaning of coal to remove sulfur-bearing waste; desulfurization of petroleum products; improving combustion efficiency to conserve fuel resources and produce less pollutants for a given energy production; and the removal of sulfur oxides from waste gases and conversion to useful products of commerce.

Mr. DADDARIO. You talk about the lack of ability to keep up with the need and you state that this is largely due to lack of funds. Have you proposed programs which would definitely be of help but which have not been supported by funding? Or is it a problem which involves the amount of funds which would allow you to develop an adequate research effort?

Dr. HIBBARD. The answer to the first question is "Yes." We have proposed programs which have not been funded. The answer to the second question is also "Yes," because the problem has increased so rapidly almost algebraically.

Mr. DADDARIO. Could you go into that a bit, and perhaps submit for the record any details that may be necessary?

Mr. MOSHER. Mr. Chairman, I would especially like to know, when Dr. Hibbard says that programs have not been funded, where this decision has been made. Was it higher up than your own department, has it been a Budget Bureau decision, or has it been made by Congress, the White House, or who?

Dr. HIBBARD. I think I will ask Mr. Perry to answer that question because I have been in my post only 9 months.

Mr. DADDARIO. That was why I said the Bureau of Mines. In addition to the points which Mr. Mosher just raised, would you talk about industry's role? How do they feel about it and what pressures have they put on you? What have they been willing to do themselves in the fields of research and technology?

Mr. PERRY. In respect to the last point you made, I believe Dr. Hibbard will discuss cooperation of industry in the latter part of his testimony.

With respect to the first point, it is a question of allocating the total resources properly and then for us to do something about the pollution problem which has really come on us only within the last 10 years in a great way.

The Bureau started as early as 1915 on the problem of smoke abatement which is what air pollution was originally called. Working with the city of Pittsburgh and others, we have attempted to see what could be done with this problem, and, indeed, we have prepared more than 200 publications in the field.

I would like to say with respect to the funding that it has been at all levels. Sometimes the decision was made internally, the choice of projects with respect to pollution put some other demands on us and we would have to put the pollution aside for the time being because in the allocation of our resources at that particular time this was not as important as other things.

I would have to say, however, that at every level there have been some financial restraints as there always are.

Mr. MOSHER. Do you have any specific examples of an occasion when you urged additional funds to develop technology or to use for research and were turned down?

Mr. PERRY. Yes, we can supply those, although I would like to say in general that since 1955 when the first Clean Air Act came in and HEW took the primary responsibility in the executive branch with respect to air pollution, we proposed those things that we felt needed to be supported. And again, within financial constraints, they have to make decisions with respect to our programs versus other needs and, by and large, my recollection is that we feel we are quite well treated when about half of our proposals are funded. I think this is a pretty good batting average.

Dr. HIBBARD. Could we supply something for the record?

Mr. DADDARIO. Yes, if you could, but what concerns us isn't so much whether you have a good batting average or not. Under ordinary circumstances I would guess 50 percent would be good, but we are considering a program which might develop vital information concerning the pollution problem and Dr. Hibbard has pointed out that we haven't been keeping up with it. We know that somewhere along the line we have got to catch up and if we are only going to be able to do 50 percent of the research necessary, I suspect we never shall. If you could provide that for the record, it will be extremely helpful.

BUREAU OF MINES POLLUTION ABATEMENT RESEARCH

In accordance with your request at the hearing on "Adequacy of Technology for Pollution Abatement," we are pleased to provide your committee with the following supplemental information on Bureau of Mines pollution abatement activities.

Before the enactment of Public Law 159–84th Congress in 1955, the Bureau of Mines was the leading Federal agency in air pollution abatement. Even though the Bureau published almost 200 technical papers on air pollution between 1910 and 1950, the funds available for this work were generally very small and most of the research was performed under "conservation" and "health and safety" appropriations. The Bureau had an Office of Air and Stream Pollution about 1950, but funds were not available to expand this office into an effective air pollution agency. Limitations on budget requests were normally made in advance of such requests. These limitations came either from the Bureau of the Budget or by Departmental directive. As a result, only the most urgent problems could be included in a budget presentation and stay within the limitations imposed. Smoke control was the principal air pollution problem eliciting public support during this period and the Bureau did obtain limited funds for work in this field. Additionally, very limited funds for acid mine drainage and mine sealing were provided during the years preceding World War II.

Public Law 159 provided that the Surgeon General, in cooperation with other Federal agencies, should recommend and perform research on the prevention and abatement of air pollution. This law provided for appropriations to the Department of Health, Education, and Welfare for the Federal air pollution program. The Bureau has cooperated fully with HEW through the use of funds transferred from that agency. In addition, the Bureau has used appropriated funds to perform research which has pollution abatement implications. The following table shows the relationship between Bureau requests for air pollution project funding and the actual funds transferred from HEW.

Fiscal year	Project funds requested	Funds received
1956	$300,000	$98,000
1957	(1)	125,000
1958	425,290	227,000
1959	481,490	227,000
1960	463,790	243,000
1961	485,690	300,000
1962	467,300	350,000
1963	791,200	450,000
1964	825,000	500,000
1965	1,013,600	600,000
1966	985,000	670,000
1967	2,116,000	[2] 759,000

[1] Unknown.
[2] Estimate.

However, the table does not tell the entire story. As a rule, the Bureau requests funding on projects it believes, from discussions with PHS officials, may have a chance for approval. For this reason, less projects are proposed to PHS than are suggested by our field scientists.

Incineration is another example where fiscal limitations have seriously restricted research efforts. In the mid-1950's, the Bureau cooperated with the Public Health Service in research aimed to develop engineering guidelines for incineration. Although good progress was made, the work was terminated when funds for Bureau work were no longer available.

It has been estimated that the Bureau's efforts in abatement of air pollution at the source would need to be expanded by a factor of about 5 if it were to be in a position to provide the much needed technologic information on the handling and use of fossil fuels. Research on solid wastes is presently funded at $4,300,000 per year, and this may need to be increased in the near future. Acid mine drainage work is performed principally in cooperation with the Federal Water Pollution Control Administration (FWPCA). The Bureau expects to expend approximately $450,000 on this work in FY 1967 in addition to contract work by private companies for direct assistance to the program. The contract work is handled directly by FWPCA.

Dr. HIBBARD. I would like to turn my attention to certain of the specific questions which are raised in chapter 6 of your report of the Research Management Advisory Panel.

With respect to question A(1), what should our basic goals and standards be? The standards set by the State, Federal, and local health agencies are based on factors such as effects on plants, animals, humans, and the general sociology of the area.

The Bureau does advise, on the basis of our research, as to whether standards can be met with available resources; preferably at the lowest total cost to the public.

If, for example, the public agency decides from a public health standpoint as to the maximum amount of sulfur compounds it should permit as emissions from fuel-burning appliances, the Bureau can advise them as to the impact of such a regulation on the availability of fuel resources.

Our goal in general is to assure the Nation of an adequate supply of minerals and mineral fuels to support the growth of the national economy while maintaining or improving the quality of our environment.

In response to question 2, and particularly with respect to waste management systems, we doubt very seriously whether new technological developments can proceed without effective systems management development. We have applied this approach to our automobile exhaust studies, and we are convinced the rewards will be great, even though our investigations are concerned with only a smal part of the overall problem.

Another example of the systems approach is the strip and surface mine study authorized in the Appalachian Regional Development Act of 1965 where we are studying the entire national problem before deciding on an approach to its solution.

The preliminary interim report of this study is in the Government Printing Office and will be available about September 1.

Mr. DADDARIO. Could you go into a little more detail as to how you used your systems management analyses in your automobile exhaust studies and as to why you believe it offers such a favorable prospect?

Dr. HIBBARD. This will be discussed a little bit later on in my testimony. In general we believe that the total problem consists of looking at the fuel and the fuel utilization device; that is, the fuel utilization system, and not necessarily confining it say to an internal combustion engine as we know it today. The exhaust is effluent from the system in relation to the function of the device with respect to the transmission of power by conversion from liquid fuel to a mechanical device. In general we look at this total system with all the variables, and there are some 25 of them. For example, if you change the carburetion or change the fuel or change the additives in the fuel, it is probable that there will be interaction between variables, and you can't really look at each one independently. We believe that the second part of this input has to do with a more detailed knowledge of the harmful aspects of the engine exhaust effluent.

We know, for example, that it consists of unburned hydrocarbons which in themselves are evidence of inefficient burning process in the engine and we know that improved efficiency of fuels combustion will help this situation.

We know that we have carbon dioxide, carbon monoxide—carbon dioxide, because it is the product of complete combustion—and nitrogen

oxides which are produced from air at the temperatures in the cylinders.

If you look at all of these variables, you can then model a system and balance the input and the information output variables. From this we can learn what must be done in terms of the functional design of an engine or of fuels utilization devices to avoid these specific compounds which are harmful to health.

And, I think from that approach you might end up designing the fuel or designing the fuel utilization system and designing an effluent control system which might well do the job of the existing internal combustion engine and may or may not look like it.

To proceed with the next question, B(1), which asks whether or not research on pollution abatement sponsored by the private sector of the economy can be stimulated and can do the job. Basic research on pollution of all kinds has not usually been heavily supported by industry inasmuch as the benefits that may accrue frequently can't be applied solely to the organization supporting the research and the monetary benefits and returns are not particularly rewarding.

In general, this is known as nonproductive research. For this reason the Government will doubtless have to play a dominant role in pollution research, and institutions of higher learning in cooperation with the Federal agencies can make valuable contributions.

In this connection, I would like to point out that air pollution is an international problem, and we are attempting to keep abreast of technology as it develops in laboratories throughout the world. The Interior Department has a working agreement with the Japanese Government on the development of natural resources, and Mr. Perry of my staff is chairman of the American panel on air pollution. This panel has met with their Japanese counterparts both in Japan and in the United States, and the results are most encouraging. Secretary Udall, accompanied by several pollution experts, recently visited Germany and a return visit by German investigators is being arranged for this fall. The possibility for cooperative research between the two countries is being explored at the present time. Likewise, close liaison between our officials and the British is providing a rapid exchange of information on all facets of the air pollution problem.

Since the private sector is responsive to competitive factors and the setting by the Federal Government of new standards would tend to disturb existing markets, industry undoubtedly would make strong research efforts to meet Federal standards in order to retain its market strength if these economic implications were applied.

With respect to question B(4), the Bureau of Mines does not have authority to contract with outside agencies.

Mr. DADDARIO. Mr. Vivian, would you like to ask a question?

Mr. VIVIAN. I was following your prepared testimony, and I noted you omitted the fact that the Bureau of Mines does not have the authority to contract with universities in most of its research areas.

Dr. HIBBARD. That is correct, sir.

Mr. VIVIAN. What is the nature of the restriction?

Dr. HIBBARD. We have authority to contract in the area of solid waste disposal and in the area of our helium activity. In all other activities we do not have such authority.

Mr. VIVIAN. Do you require authority or is authority automatically implied?

Dr. HIBBARD. Our solicitor has advised us that we do require authority. There are bills pending in both Houses of Congress now which if they are passed and signed into law will give the Secretary of Interior authority to contract for research in those programs which have been authorized by statute. This will help us no end if we can get this authority.

Mr. VIVIAN. Would you be so kind as to identify these bills?

Dr. HIBBARD. Yes. They are H.R. 15316 and S. 3460.

Mr. VIVIAN. Thank you.

Dr. HIBBARD. You are welcome.

Mr. MOSHER. Do you think it is possible that industry associations can be used to pool efforts and benefits?

Dr. HIBBARD. I will discuss that later in the testimony. We do have some joint venture research contracts with industrial associations where we both contribute use of equipment. These have been very useful and fruitful, particularly where we have identified a new area of technology which we would like to transplant into industrial practice. A joint ventur effort of this sort is a very effective method of transferring technology from a Federal research laboratory to industrial technology.

Mr. MOSHER. You will be discussing this later?

Dr. HIBBARD. Yes.

With respect to question B(6), we believe that the opportunities are unlimited for approaching a recycle type of industrial society, one in which materials are used over and over again. This is a very challenging area and should involve again, a systems approach, such that a material and its use in a device are designed, not only for its primary function but also for optimum recovery, recycling and reuse.

We believe for example, that one can design alloys in such a way that they will have the same kinds of strength characteristics and yet not contain those kinds of alloying additions which are difficult to remove during the recycling process.

We believe that one can design various components, say of an automobile, so that they could be readily disassembled in the scrap yards and separated for reuse as scrap. In fact, we have a study aimed at this kind of approach to the problem. We think it is very promising and in the long run it is going to be the long-range solution.

With respect to question C(1) regarding the funding of, the balance between short-term and long-range problems, many of the problems concerned with pollution abatement have social connotations and tend to obscure definitive answers as to the comparative merits of short- or long-range remedies through research. It should be remembered that the time required for basic research necessary to the successful use of technology is often a 5 to 10 or 15 year span. Thus, if one is to start from a basic research approach, the start must be made well in advance of the need for solution to the problem.

For example, we recognized and started to work on the junk automobile problem 7 years ago when we noticed the metallurgical changes which were going to result from the use of the basic oxygen furnaces and the use of hot metal instead of scrap. We are now ready to build

a demonstration plant because we anticipated this problem. One is being planned and has been funded and will be put in operation to work out the economics of a process for recycling automobile scrap.

Mr. ROUSH. Where will that be located? Have you determined that yet?

Dr. HIBBARD. The location, I believe, hasn't been announced yet. This particular process involves presently unusable low-grade iron ore—nonmagnetic taconites from the Mesabi area—which are roasted with automobile scrap to yield a magnetic form of easily recovered iron ore. The process not only reuses the auto scrap, but it also gives value to a large reserve of iron-bearing material which hasn't been economic to treat heretofore.

Mr. ROUSH. Does this appear to be an expensive process?

Dr. HIBBARD. No, I believe it won't, but it must be tested on a large enough scale before one can be sure. The process is simple enough. It involves taking automobile scrap which has been cut into chunks of this size, and passing it through a suitable rotary kiln at a modest temperature along with the nonmagnetic taconites and out the other end comes an enriched iron ore which is then very useful. So, I would anticipate this to be economically very attractive. The major limitation will be the cost of transportation of junk automobiles.

Mr. MOSHER. When you build a demonstration plant such as this, is it operated completely by your own department, or is it done in conjunction with some industrial organization?

Dr. HIBBARD. This can be done several ways. In this particular case we are going to contract for the building of the plant but we will operate it ourselves.

Mr. MOSHER. Strictly for demonstration?

Dr. HIBBARD. Yes, sir. The purpose here is to demonstrate successfully the sound economics of this process, and by so doing we believe that industry will pick it up from there. So, this is solely a demonstration.

Mr. MOSHER. Before making that decision, did you consult with industry?

Dr. HIBBARD. Oh, yes.

Mr. MOSHER. On the possibility that some concern would do this?

Dr. HIBBARD. Yes, sir.

Mr. MOSHER. In cooperation with you?

Dr. HIBBARD. In fact, this is the result of 7 years of research which we have reported to industry through our regular publications. We have in our laboratories at Minneapolis, our Twin Cities research laboratories, a laboratory scale pilot plant. We brought people out to see it and get their advice and counsel and recommendations before we decided to proceed with the demonstration plant.

We then made the proposal to our appropriations people and they thought it was a good idea to proceed.

Mr. MOSHER. But, no industry or industrial concern was willing to gamble on doing this on their own?

Dr. HIBBARD. If this had been the case, our general policy is to pull out and give it to industry just as fast as they will take it.

Mr. VIVIAN. Mr. Chairman.

Mr. DADDARIO. Yes, Mr. Vivian?

Mr. VIVIAN. I would like to ask a question since we have large taconite ore supplies in my State of Michigan, and these supplies happen to be a long distance away from where the cars are made, used and fall apart. The question I have is, why is it advantageous to put the taconite——

Dr. HIBBARD. I am not hearing you.

Mr. VIVIAN. Why is it advantageous to put the taconite, which is found far away from where the automobiles are junked, together with the junked automobiles in one blast furnace or equivalent device instead of putting them into separate furnaces at separate locations and transporting less material around the country?

Dr. HIBBARD. One of the things that we are doing is making a junk automobile survey so we will know in what locations the population of junk cars are and what the problems are with transporting them and other information of this sort.

We believe that the solution to the problem is not going to be a single one; there must be a menu of solutions, so to speak, so that you will have one that will fit the economics of each area where there are large concentrations of cars. We believe the taconite approach is one solution.

Mr. VIVIAN. Just a minuite. Before you say this is a solution, is this solution any better than melting down the cars in one place, preparing the taconite material some other place, and later mixing them in a furnace some distance away from both locations? What is the advanagte of this joint process? Chemically and technically?

Dr. HIBBARD. I see what you mean. I think the logistics, the optimization of logistics haven't been really worked out. It might well be that a different location of the plant might be more fruitful. However, in general, since the taconites are low in iron, you would tend to minimize the transportation of the lowest value raw material of the process, and that would be the nonmagnetic taconites themselves, so you would tend to minimize the transportation of low value material and maximize the transportation of the high value material. Following that principle you would put it near the taconites. This may not be correct when we have all the economics.

Mr. VIVIAN. I really have difficulty seeing this. Michigan is a major taconite State. But it seems strange to take the cars which are junked in Chicago or Detroit and other places where the bulk of the population lies, put them aboard a lake freigher and haul them up to the northern part of the State which is, I suppose, 600 miles away by water, then mix them with taconite derivitive materials obtained locally, and ship them all back down. It is not obvious to me that you have added any benefit to the furnaces that wasn't there in the first place.

Dr. HIBBARD. The furnaces as they now exist cannot just use the junk automobile scrap because, with the advent of the basic oxygen furnace, these furnaces do not use No. 2 bundles which are the old automobiles.

Secondly, the furnaces cannot use the low-grade nonmagnetic taconites as they now exist because they are too low in iron. These are taconites that are 20, 25 percent iron, large amount of silicates and impurities. So, by combining two things which the furnaces can-

not now use and making out of them these metallized pellets, you end up with a material in the form which the furnaces can use.

Chairman MILLER. In many instances, isn't the taconite prerefined near the mining place?

Dr. HIBBARD. Yes.

Chairman MILLER. And, it can be refined there until it gets rid of the surplus materials, as I understand the process.

Dr. HIBBARD. In general, the taconites that are used are magnetite which is magnetic, and in some cases hematite, which are between 64, 65, and maybe 80 percent iron in their contents. These are pelletized and roasted and so-called metallized to the point where the material increases in its iron content to maybe 80 to 90 percent.

However, with the present economics, the so-called low-grade nonmagnetic taconites are not used. These are taconites which have only 25 percent iron.

Chairman MILLER. I know; I was in Australia about a year ago and they have made some great discoveries. They are now shipping taconite to Japan, I believe.

Dr. HIBBARD. In the western part of Australia as you know they have these tremendous mesas which are solid hematites. They are just beautiful. In fact, they are equivalent if not better than some of the Mesabi ores. We would just love to have this in the United States.

Mr. MOSHER. Are you saying, sir, that there is less bulk in the compressed junk automobile than there is in the taconite and therefore it pays to ship the less bulky car junk to the taconite.

Dr. HIBBARD. The percentage of iron per pound in the junk automobile as it is chopped up and shipped is much higher than the percentage of iron per pound in the taconite.

So, under normal circumstances you would move the junk autos to the taconite and not the taconite to the junk autos.

If I could move on there are some answers to other questions in the testimony. I move to question C(5), the question of the fragmentation of research. I think there are examples where research has been fragmented and where a piecemeal approach has been used to solve one problem while creating another.

A good example would be a use of aqueous scrubbing of flue gas to remove sulfur oxides. This might remove the sulfur oxides from the stack effluents but would form low-grade dilute sulfuric acid which would be very difficult to dispose of, either causing a stream pollution problem or a solid wastes pollution problem to replace the atmospheric one.

Again, we believe that the systems approach can help here.

I would like to also move to question E(1) regarding the Federal, State, and local problems of applying technology. We have a good example of State-Federal cooperation in our own area. The Appalachian Regional Development Act calls for demonstration projects concerning the alleviation of surface subsidence over mines, putting out of coal fires, and incidentally there are over 200 coal beds in this country which are burning right today. They are bellowing smoke and causing the loss of good coal and are general problems in health and safety.

In the other area is strip mine reclamation. We have projects with the States on these subjects which are currently confined to public lands where the State proposes the demonstration work to be done and it is funded jointly on a 75 Federal, 25 State basis. We work together working out the engineering and other details of the project and in reporting.

I would like to turn quickly, if I may, now to the current status of pollution abatement technology, in my opinion.

The scientific information on pollution information is for the most part more advanced than the engineering technology. There are theoretical chemical equations for handling many of the pollutants from the standpoint of their formation and from the standpoint of their alleviation. However, the problem is that the corresponding engineering technology either hasn't been developed or, if you include in the definition of technology the question of economics, the economics are unfavorable.

This does not mean that we recommend no further basic research because, as a strong supporter of basic research, I believe that it is reasonable to expect that a better understanding of the fundamental processes involved in pollution formation and prevention would lead to more feasible avenues for developing technologies.

However, one would hope to use, wherever possible, existing technology because of the timespan involved and, therefore, it is the technological area where we are in short supply.

One of the major reasons for this is because most pollutants are in a very low concentration in the environment and therefore the removing of relatively small amounts of materials from very large volumes of harmful substances is generally an economic problem.

Incineration of combustible refuse is a good example of moderately adequate scientific information but very inadequate engineering technology. I state that the scientific background is fairly well known because incineration is basically a combustion problem. Since incineration is a combustion process, it should be possible to design incinerators on the basis of the theory and practices of burning solid fuels such as coal. However, whether it is a small household or a large municipal incinerator, the design and operation is complicated by enormous variations in the quantity and composition of the refuse fed to the furnace. These variations in the feed cause significant fluctuations in the temperature of the combustion chamber which creates serious problems in controlling the evolution of smoke, fly ash, and malodorous or noxious gases. In addition, combustion control is complicated because the moisture content of the combustible refuse may vary from almost zero to at least 80 percent. All too often, municipal incinerators are designed and built without adequate attention to the nature and volume of the materials they must handle at the outset, let alone within the next decade. Residential incinerators generally are inadequate for the job and are operated by unskilled personnel. Unfortunately, basic and applied research on the incineration process has been notably scanty. The Bureau of Mines and the Taft Engineering Center conducted limited investigations on incineration in the 1950's, but the work was terminated long before completion. Limited research has been conducted in recent years by a num-

ber of organizations, notably, New York University, but the field is wide open for systematic research on both the combustion and the gas-cleaning phases of the incineration process.

I would like to move from here to the sulfur oxides problem.

The principal sources of sulfur oxides are from the combustion of fossil fuels and from the metallurgical processes involving sulfur-bearing ores. There is no industrially proven method presently available for appreciably lowering the sulfur oxides released through combustion processes. There are in development and in pilot plant stages, however, several ways of approaching this problem. It may be approached in at least two ways. One would be to remove sulfur-bearing compounds from the fuels before burning. In coal, for example, sulfur appears in two main forms—as discrete particles of pyrite (iron sulfide) and in the organic structure of the coal itself. There is no presently known method for removing the organic sulfur without destroying the coal molecules, but the sulfur occurring as pyrite can be separated mechanically. The reconstitution of coal, that is, dissolving the coal and reprecipitating it, leaving the sulfur behind is of course, a very expensive process, but it will remove organic sulfur.

The pyrite can be separated by physical means. One must grind the coal to the point where the particle size is equivalent to the pyrite size and then remove it magnetically or by other methods. The larger size particles can be removed by conventional cleaning methods.

The situation with respect to removal of sulfur from petroleum and its products is somewhat more complicated. The American crude oils are generally low in sulfur, sufficiently so as to yield an end product which is not high in sulfur. However, for economic reasons the percentage of crude oil converted to residual oil is rapidly decreasing because the price of residual is roughly half that of crude. Therefore you are not likely to make a low-valued product from a higher one, so the economics are not good.

As a result, the Eastern Seaboard States are increasingly dependent on overseas shipments and a large part of this imported residual oil is a high-sulfur product ranging from 2 to 3½ percent sulfur. There are scientifically feasible methods known for the desulfurization of fuel oils. For example, hydrodesulfurization is scientifically possible but economically this would be very expensive. It would increase the cost of residual fuel by at least 25 percent, and seriously affect its economic competitiveness.

Another approach is to remove the sulfur oxide from waste gases resulting from the combustion. There are several methods for doing this. The wet method or scrubbing method is not practical because it reduces the temperature of the gases to the point where they don't float out in the atmosphere, but are inclined to crawl out of the smokestacks and settle back down on the surrounding environment.

The other methods include an approach which is an absorption technique.

The approach which we are following in the Bureau and which is sponsored by HEW is the use of alkalized alumina to absorb the SO_2 from the effluent at high temperatures. This has the advantage that the absorbent will be regenerated, and we obtain sulfur from the process. Sulfur is in short supply, so this process can be used effectively as a conservation measure.

Another approach is to mix the fuel with certain materials, such as limestone or dolomite and other materials which combine with the sulfur in the furnace and form a sulfate which remains with the ash and can be removed from the effluent as a particulant. There are areas where this is possible.

We believe there is no single approach to solve this problem. The real problem at this stage of the game is to determine the cost of these various methods and to see under what range of circumstances they are feasible.

Our present program is, again, a systems approach, and the items involved here are to study the coal and oil resources in terms of their sulfur content, develop selective mining operations for leaving behind the sulfur-containing materials, the fixation of sulfur during combustion, or the desulfurization of the waste gases. With this combination I believe, when successful, we will have the techniques to help solve this problem.

A second major area——

Mr. VIVIAN. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Vivian?

Mr. VIVIAN. The question I have is this:

What is the impact of having a large amount of sulfur oxide dispersed into the atmosphere?

Dr. HIBBARD. Our mission is technical in this case, and we are not competent in the health aspects of these effluents.

We have been working very closely with the Air Pollution Division of the Public Health Service, coordinating our activities and relying entirely upon them for the appraisal of the health aspects and the discussions which involve what are threshold amounts of sulfur oxide. They set the goals in effect and we are trying to achieve them.

Mr. VIVIAN. I presume that some of the sulfur oxides wash out with rains and are deposited on the earth's surface.

Dr. HIBBARD. Yes.

Mr. VIVIAN. Is there any observable reaction that results from this?

Dr. HIBBARD. In general any combination of sulfur oxide in the presence of oxygen and water will result in some form of acid either sulfurous or sulfuric acid, and the concentration of this is dependent upon the particular situation involved.

Mr. VIVIAN. I am trying to find out the impact. I take it that this is a subject you people don't get into?

Mr. PERRY. The concern with sulfur oxides relates only to health effects, and not with respect to the appearance of sulfuric acids.

Those concentrations would be very low.

Dr. HIBBARD. This is a breathing effect, or an interaction of plants.

With respect to auto exhausts, this is a very serious problem because the approaches which are now being taken, and very ably so, are based on existing technology and will not solve the long-range problem of the mounting number of automobiles.

We believe therefore, as we mentioned before, that there should be a systems approach to the long-range solution which will permit a minimum amount of harmful effluent. The problem should be looked at from the basic principles problem and not simply the conversion of existing systems as they now are used.

Mr. DADDARIO. Is there a conflict between your statements as to your activities and those of the Department of HEW and the fact that motorists will be spending about $50 for antipollution devices for cars which, when multiplied by 10 million cars, amounts to one-half billion dollars? You say that while many of the compounds present in automobile exhaust are relatively inactive, only a few of these constituents of the exhaust are the primary cause of pollution. Are we just doing this because it creates a positive psychological effect in the minds of people that something is being done when, in fact, we are spending all of this money just to get rid of a few of the constituents of exhaust?

Dr. HIBBARD. The problem is particularly with the unburned hydrocarbons which come out of an engine as automobile exhaust. There is a wide variety of these, and we are systematically—and when I say "we," I mean the Federal Government as a whole—analyzing these compounds to find which of them are the harmful ones and which are not.

The problems are so complex and so numerous that at the particular moment we don't know which of these are of most importance—well, we do know certain of them are bad actors, but we don't know that all of them are bad actors; and we haven't yet sorted out the harmful ones from the nonharmful ones.

In addition, as you know, there is still a controversy, even with respect to smog—whether this comes from the interaction of the nitrogen oxides with hydrocarbons—and how important this is to the smog abatement problem.

We really don't know at the moment as much as we should about the characteristics of the engine exhaust effluents and their interaction with the variables of the fuel and the engine parameters of the automobiles itself.

These are the first things which we must obtain. HEW is proceeding to get this kind of information; we are too.

Mr. DADDARIO. Do we know enough about it so that we should impose on the public the burden of paying for this $50 device? Is it worth it, or should we revise our thinking about this situation and divert these expenditures so that they will be more effective?

Dr. HIBBARD. I believe that anyone who has been in the Los Angeles-San Francisco area during the time when smog has been particularly bad—and I have been there in those times—I firmly believe that there is too much air pollution from engine exhaust.

The kind of regulation which is now taking place is reducing this and I certainly believe it should be reduced.

I don't think we are ready yet to say precisely to what extent it should be reduced and precisely how it should be reduced, but I think the kind of regulation we have is good.

Mr. DADDARIO. This seems to fit into a category of problems about which we are usually given the following advice. You can spend a billion dollars, let's say, and it will achieve some benefits, but it will not obtain all of the benefits. There is some question that after you have spent all this money the situation hasn't gone beyond the point where it was when you originally started only because you didn't know enough about it in order to impose this obligation such as the $50

device on the buying public in the first place. And, I would like to add to that if, in fact, the program doesn't achieve the most beneficial results, you break down the desire of the public to support future programs. It is on this support that we ultimately have to depend.

Dr. HIBBARD. I believe in this case there will be beneficial results. The general prognostication is that the engine exhausts or effluent will actually decline with time as a result of the regulations which are now being considered and the technology which is now being developed, but that it is the sheer number of automobiles which is going to cause it to go up again and require eventually a longer range solution.

Mr. DADDARIO. Maybe I can put it this way. If you had the half billion dollars to spend, would you spend it this way?

Dr. HIBBARD. Gee, that's an awful hard question to answer. I suspect many of the things that are now being done I would do. Maybe not all of them. I don't know.

Mr. DADDARIO. I'm talking about the $50 device. It comes to half of a billion dollars. You know what it is going to achieve. You have already said that there are problems the nature of which we don't presently understand. We are talking in the final analysis about half of a billion dollars in this one narrow area.

Dr. HIBBARD. I believe that this research will——

Mr. DADDARIO. And, I'm reminded properly that we are not talking about a total of half of a billion dollars. We are talking about half of a billion dollars every year in an area about which we know so little.

Dr. HIBBARD. I believe, from what I understand, that the general objectives of this device, is to provide information which is essential to the solution of the problem and it will in addition produce a short-range solution which will give us time (8 to 10 years), to tackle the longrange problem. I think those are desirable objectives.

Now, from the standpoint of cost effectiveness, I really am not in a position to evaluate whether it is worth this kind of money.

Mr. DADDARIO. I don't mean, of course, to have you make a snap decision on a situation such as this, but I would expect that you would support the general theory that we ought to know more about certain areas within which we push expenditures of large sums of funds before we commit ourselves.

Dr. HIBBARD. Yes. The only exception I would take to that is that frequently the engineer is faced with making a decision about a problem before he has all the information needed to make a really sound decision.

We may be in this kind of a situation now, and this happens many times.

Mr. DADDARIO. Well, there is no question, that if we could reach the point where we could find an infallible solution to a complicated problem such as this, we wouldn't be having these meetings today.

But, as I have listened to testimony here and as we have prepared ourselves for this meeting, there seem to be a multitude of problems the solutions to which seem to be extremely hard to find. We ought to be able to sort these out and come to some understanding about where we stand and how we can approach them.

Dr. HIBBARD. I quite agree with that.

In other words, I believe that by taking the total problem and looking at it on a systems basis, we could come to some kind of a distribution of the work to solve all of the problems involved.

Mr. DADDARIO. You touch on mine drainage for example. Is it possible that there is no solution? Acid drainage occurs naturally in some places. If we come to the conclusion that there is no solution and that pollution from mine drainage is more of a natural phenomena than anything else, should we accept it and explain why it is?

Dr. HIBBARD. No; I believe there is a solution to the problem. At the moment the solutions which are known are very expensive. It would cost, I would say, in the billions of dollars to solve the problem in Pennsylvania alone.

Mr. DADDARIO. But, because this is such a big problem and because it raises such havoc in certain areas, it ought to be known that we are still groping with the problem. We ought not to panic because people are so disturbed about it and spend money only so as to give the appearance that something is being done.

Dr. HIBBARD. I quite agree. This problem can be solved. It can be solved economically, I believe. It is going to require a sensible research and development program. If we approach it in an orderly way, it will be solved.

Mr. DADDARIO. Mr. Chairman?

Chairman MILLER. We look at some of these problems and we see the immediate effect in our own areas. We sometimes overlook them when they don't affect us directly. I'm conscious of the fact that in California when Shasta Dam was built they had to seal off a number of old copper mines. I have often wondered how long the seals of these mines are going to last under heavy heads of water? What will happen if these seals break?

Dr. HIBBARD. I don't know, but it will be very unfortunate.

I have touched briefly before on the solid waste in the junk auto program. I think the two points I would like to emphasize, the extraction processing and utilization of mineral substances frequently is a cause of solid waste. When you think that an ordinary copper ore contains about half a percent of copper—this means that there are only 10 pounds of copper for every 2,000 pounds of ore—you have a large amount of material to dispose of.

The Bureau has been approaching the problem of minimizing or utilizing wastes and has concentrated on areas of improving systems which would reduce the mineral losses and control the volume and location and products finally discarded. It has endeavored also to use waste to fill and support old mine openings.

Again here, the system approach appears to be essential. One example I would like to make is the problem of burning culm banks. These are waste piles from coal mines and consist of slag and debris and some low-grade coal which has been piled out in the dumps. Frequently these have caught fire for various reasons. There are four interrelated problems involved here. One is the air pollution from the smoke of the culm fire. Another is the solid waste disposal of the piles of debris. There is a problem of pollution from the run-off of rain water into the streams, and there is the whole question of trying to conserve the coal in the piles. Therefore, this is a good ex-

The problems of environmental pollution are, to a large degree, a byproduct of our economic progress, as well as past neglect and apathy. Our scientific knowledge of the causes and character of environmental pollution is more extensive than the technology to handle the waste byproducts of our industrial civilization. Because of our failure to undertake adequate measures to prevent and treat pollution, the American people have finally come to a general realization that the air we breathe is laden with products foreign to the original environment, our water supplies are contaminated by waste products, and our landscapes are being despoiled by waste materials for which we have found no good hiding places nor any feasible methods of utilizing or destroying them. The situation is becoming more critical each day as the trend toward population concentration in urban centers continues.

ROLE OF THE BUREAU OF MINES

The Bureau of Mines, by its organic act, is charged with the responsibility to conduct scientific and technologic investigations in the mining, preparation, treatment and utilization of minerals and mineral fuels with a view of improving health conditions, increasing safety and efficiency, and conserving our resources through prevention of waste. In accordance with its original Congressional mandate, the Bureau has been engaged for more than 50 years in research investigations designed to conserve our natural resources, and in many studies aimed at minimizing pollution. Over the years, much time and effort has been expended on investigations to decrease the amount of pollutants entering our water supplies as a direct, or indirect, result of mining operations. These investigations include: acid mine drainage alleviation through mine sealing; economic means of utilizing or disposing of mine wastes; and prevention of contamination by leaching of mine tailings. While we feel we have made progress in these endeavors, problems have been arising even more rapidly than the solutions.

In the field of air pollution abatement, the Bureau of Mines has published over 200 treatises based on its work. For many years the Bureau has been a leader in the battle for the elimination of smoke which tended to cover so many of our industrial centers, and has been active in other aspects of smoke control. While this battle has not been completely won, industry and government have developed economically feasible methods of controlling the largest proportion of the smoke resulting from the combustion of fossil fuels. Likewise, the Bureau in the early 1920's initiated research on fumes released by internal combustion engines, and has continued active investigations leading toward the use of fuels with minimum pollution by motor vehicles. However, the Bureau's research and investigations have not kept pace with the incremental growth of the problems resulting in part from the tremendous increases in the number of automobiles, trucks, and buses. Owing largely to lack of sufficient funds, work on the technology for pollution control has not been sufficient to cope with the needs.

The Bureau also has a long-standing interest in the reduction of sulfur oxides pollution resulting primarily from the combustion of fossil fuels and metallurgical operations. Investigations of particular note which we have conducted, include: the cleaning of coal to remove sulfur-bearing waste; desulfurization of petroleum products; improving combustion efficiency to conserve fuel resources and produce less pollutants for a given energy production; and the removal of sulfur oxides from waste gases and conversion to useful products of commerce.

COMMENTS ON THE REPORT OF THE RESEARCH ADVISORY PANEL

With this long-term background of scientific and technologic effort in the field of pollution abatement, the Bureau is most pleased to endorse much of the report of your Research Management Advisory Panel on this subject. In particular, we wish to draw attention to the viewpoints expressed in the first paragraph of the section entitled, "The Need for Additional Technology." While it must be recognized that the environmental pollution problem is much broader than the samples cited in this section, the illustrations given are among the more pressing problems now confronting the Nation. Industry and Government can, I am sure, develop economically feasible ways to improve the environment in which we live. The necessity for such improvement is only too apparent.

Before discussing, in more detail, specific problems in environmental pollution and the research efforts underway in the Bureau of Mines in its search for solutions to these problems, I would like to address myself to some of the interesting questions designated in the report as issues worthy of consideration by the Congress. Many of the issues fall beyond the scope of Bureau involvement, but on others we do have definite ideas that I would like to present to you.

While the Bureau of Mines has a significant role in pollution prevention, we do not set the standards which the public must comply with. Standards are set by Federal, State and local agencies based on factors such as effects on plants, animals, and humans. The Bureau does advise, on the basis of our research, as to whether standards can be met with available resources and, preferably, at the lowest possible cost to the public. In other words, if a public agency is undecided from a health standpoint as to the maximum amount of sulfur compounds, for example, it should permit as emissions from fuel-burning appliances, then we can advise as to the impact of any regulation on the availability of fuel resources.

We doubt seriously whether new technological developments can proceed effectively without waste-management systems analyses. In fact, we view this approach as indispensable in determining significant "pay-off" areas to which the technological effort should be directed. The problems involved in pollution abatement are national in character and technologically complex. To achieve success requires the utilization of the most sophisticated techniques available. We have applied this approach to our automobile exhaust studies, and we are convinced that the rewards will be great, even though our investigations are concerned with only a small part of the overall problem.

Since the private sector of the economy is highly responsive to competitive factors, the setting by the Federal Government of new standards would likely disturb existing markets for fuels. Industry would undoubtedly make strong research efforts to meet these standards in order to retain or strengthen its markets.

Basic research on pollution abatement of all kinds is usually not supported heavily by industry since the benefits that may accrue frequently cannot be applied solely to the organization supporting the research, and the monetary benefits are not particularly rewarding. For this reason, Government will doubtless have to continue to play a dominant role in this research area. Institutions of higher learning, in cooperation with Government agencies, also can make valuable contributions. Unfortunately, the Bureau does not have the authority to contract with universities in most of its research areas.

We believe that the opportunities are unlimited for approaching a recycle type of industrial society—one in which materials are used over and over and over again. Many of the constituents in environmental pollutants are worth conserving, and since conservation is a major role of the Bureau, we are alert to the possibilities. For example, the recovery of the sulfur from the sulfurous gases resulting from combustion of fossil fuels would solve the critically short supply of sulfur that now exists on a world-wide basis. Likewise, the scrap automobile and discarded refrigerator that in abandoned form blight the landscape contain many valuable metals that should be recovered and put to renewed use.

The issues raised in the Advisory Panel Report having direct implications to the Federal Research and Development Program, especially those which apply to the Bureau of Mines, were carefully reviewed by us. Many of the problems concerned with pollution abatement have social connotations that tend to obscure definitive answers as to the comparative merits of short- or long-range remedies through research. Under the present budget structure of the Bureau, we believe our research effort is properly balanced between those studies that lend themselves to the application of previously developed techniques with the view toward an expeditious solution of the problem and those that require a more extensive investigatory period where ultimate success is more uncertain.

The question whether the research effort is properly distributed among the various facets of a common problem is always difficult to assess, and the different sources and types of pollution represent a classic example of the task that confronts management in the effective direction of a research program. We believe that the systems approach will provide material assistance in this area, and it is one of the reasons that we so strongly endorse this method.

The ultimate goal of the Federal research establishment in determining the appropriate stopping place as you move from basic or applied research into the

development stage, and eventually into engineering application, does not lend itself well to predetermined standards. For most engineering developments, the Bureau of Mines tends to stop short of the application stage. Once our research effort has advanced to a showing of feasibility and our results are made available to the public through discussion and publication, our role becomes one of encouraging application by the private sector. At times, completion of the development work calls for close cooperation between the Bureau and industry by formal agreement. The public interest is always protected in arrangements of this type as the Bureau retains all publication and patent rights from such joint studies. It should be noted, however, that there may be certain important research and development areas where there is little or no incentive for the private sector to become engaged. If investigatory studies in these areas are in the national interest, as for example acid mind drainage from abandoned mines, Government has no choice other than to explore these fields to the extent needed and in the required depth.

The question raised in the report with respect to a tendency to fragment research as to source or environment sector is particularly interesting. A good example of a piecemeal approach would be the use of aqueous scrubbing of flue gas to remove the sulfur oxides. This method might provide a satisfactory solution for the cleaning of the stack effluent of sulfur dioxide, but the disposal of the acid formed might merely create a stream pollution problem to replace the atmospheric one. We are fully aware of the management problem that is involved here, and therefore are again looking to the systems approach to aid us.

PRESENT STATE OF POLLUTION ABATEMENT TECHNOLOGY

In addition to the views I have just expressed on the broader aspects of the problem, I believe your committee would be interested in our evaluation of the present status of scientific information and engineering technology, as it applies to air pollution abatement and the future needs in this field if an improved environment is to be attained. As I indicated before, scientific information on pollution abatement is for the most part more advanced than is the engineering technology. There *are* theoretically sound ways to prevent the formation of many environmental pollutants, or ways of handling the pollutants after their formation but before their discharge into the atmosphere, into our water sources, or onto the land. For many pollutants, there is experimental information which can be applied to the solution of particular environmental problems. However, the corresponding engineering technology either has not been developed or the economics are unfavorable by today's standards. The costs of the remedies thus far are not considered to be worth the gains. This should not be interpreted to mean that we recommend no further basic investigations regarding pollution abatement. On the contrary, it is reasonable to expect that a better understanding of the fundamental processes involved in preventing the formation of pollutants, or in disposing of the pollutants, would reveal more feasible methods for their removal by recognized engineering procedures. However, for most of the problems, there already exists appreciable scientific information on which to base larger scale work to improve engineering technology necessary for successful solution of the problems on an industrial scale. One reason for the large gap between scientific understanding and practical solutions is the fact that most pollutants released to the environment are present in low concentrations and require removal of small amounts of material from large volumes of harmless substances. Testing of prototype equipment or processes thus can involve treatment of huge quantities of materials at substantial expense.

SULFUR OXIDES

The problems encountered in lowering the amount of sulfur oxides which enter the ambient atmosphere offer a good example of the status of many of the problems in environmental pollution. I will, therefore, discuss this in more detail. The principal sources of sulfur oxides pollution are from the combustion of fossil fuels and from the metallurgical processes involving sulfur-bearing ores. Of these the combustion of fossil fuels constitutes by far the largest source. However, since fossil fuels are the basis for the production of the predominant share of the energy which keeps our industrial economy going, there is no way to eliminate completely the use of sulfur-bearing fossil fuels within the foreseeable future.

While specific ambient air quality requirements with respect to the effects of sulfur oxides on health are subject to controversy, there is general agreement that the rapid increase in the release of sulfur oxides to the atmosphere must be curbed, particularly in highly urbanized areas. On the other hand, there is no industrially proven method presently available for appreciably lowering the sulfur oxides released through combustion processes. Nevertheless, much information on the subject is available. Even though technologic developments are progressing rapidly, the solution to the problem may still be several years away.

The abatement of sulfur oxides pollution from combustion processes can be approached in two ways. One way, seemingly the most logical, would be to remove sulfur-bearing compounds from the fuel before the fuel is burned. For example, sulfur occurs in coal in two principal forms; that is, as discrete particles of pyrite and in the organic structure of the coal molecules. There is no presently known method for removing the organic sulfur without destroying the coal molecules, but the sulfur occurring as pyrite can be separated (at least theoretically), by physical methods. In most American coals, the iron pyrite occurs in a wide spectrum of particle sizes, the larger of which can be removed by conventional cleaning methods.

American coals range in sulfur content from about 0.5 percent up to a maximum of 6 or 8 percent. The United States does have an appreciable quantity of low-sulfur coal (less than 1 percent sulfur), but much of this product is not readily available to the utility market, because most of these low-sulfur coal mines—many of them so-called "captive" mines—are producing primarily for steel-making and other metallurgical purposes. Although these reserves of low-sulfur coal might be used in an emergency to serve this market, any sudden large demand would require an appreciable time period for development of new, additional mines in known low-sulfur reserves.

While the reserves for petroleum are much less than for coal, they still are extensive and do not represent a supply problem in the near future. For the generation of electric power, space heating and small manufacturing operations, heating oils and residual fuel oils are the primary liquid petroleum products used. The situation with respect to the removal of sulfur from the petroleum and its products is somewhat more complicated. Most American crude oils are sufficiently low in sulfur to produce an end product (residual fuel oil) which is not extremely high in sulfur. However, for economic reasons, the percentage of crude oil which is converted to residual fuel oil is rapidly decreasing in the United States. While ten years ago approximately 14 percent of the crude petroleum ended as resident fuel, today the figure is only about 7 percent. As a result, the Eastern Seaboard States are increasingly dependent upon imports of residual fuel oil, and a large share of the imported residual oil is a high-sulfur product ranging from 2 to 3½ percent sulfur. Scientifically feasible methods are known for the desulfurization of fuel oils, but these processes are not considered economically feasible at the present time. Recent estimates on the cost of desulfurization indicate that lowering the sulfur content to below 1 percent would probably increase the cost of residual oil by at least 25 percent. Whether economically more attractive processes can be developed cannot be stated with certainty. Many petroleum experts are pessimistic regarding the future of desulfurization, but since it is feasible scientifically there is need for increased efforts to find less costly processes.

Another approach to reduction of oxides of sulfur in the atmosphere is the desulfurization of waste gases resulting from the combustion of fossil fuels. Wet methods for the removal of oxides of sulfur from stack gases have been investigated for many years, but such methods have not proved successful. Present technologic efforts are directed toward absorption processes which can be used without cooling the waste gases. At least three or four processes look promising, but almost all of the engineering development work is yet to be done.

The magnitude of the engineering problems which are encountered in this work can be appreciated from the fact that an 800 megawatt electric utility plant discharges over three million cubic feet per minute of hot gases from the smoke stack. If the fuel burned contains approximately 3 percent sulfur, the waste gases contain approximately 0.2 percent sulfur oxides. The equipment required for the removal of these oxides from such a large volume of gas is very costly and will occupy a relatively large space in or around a powerplant. It has been estimated that the capital cost of equipment for removing sulfur oxides

from the waste gases will run from 10 to 20 percent of the cost of the utility plant. Additionally, many existing plants do not have sufficient space in which to place this added equipment. Also, the capital cost is so high that it is questionable whether these methods can be used by smaller space heating installations.

In addition to the waste gas absorption processes now under most active development, there are many less sophisticated methods or systems that have been proposed which may prove to be more successful than those now under development. In any case, a partial solution to the problem will probably be found within the next few years and research now underway may provide more feasible methods for an overall solution to the sulfur oxides problems. An additional factor which the Bureau of Mines research has taken into account is that sulfur or sulfuric acid, which could be recovered, is presently in world short supply.

A third approach for the removal of sulfur oxides bears promise of providing a solution applicable to certain combustion processes. In this process, the oxides of sulfur are fixed during combustion by the use of an additive material such as powdered dolomite or limestone which are low in cost, and the resulting calcium or magnesium sulfate can later be removed as a solid by methods similar to those used for removing particulate matter from gases. The information presently available is insufficient to assess the true potential of the process.

However, it may prove of appreciable importance both for small installations which cannot afford the high capital expenditures for removing the sulfur oxides from the stack gases, and for existing large plants where there is insufficient space to install the large amounts of additional equipment.

It has been shown that no single approach will solve the sulfur oxides pollution problem. For this reason, we believe a systems approach will prove most fruitful. A program is under study in the Bureau which will consider technologic development needs in terms of recognized air quality requirements. This systems approach will include: studies to delineate our coal and oil resources in terms of their sulfur content; selective mining operations; desulfurization of the fuel before combustion; fixation of sulfur during the combustion process; and desulfurization of the waste gases before release to the atmosphere. Interrelationships between process factors will be studied to assure the development of a method or combination of methods which will give the desired air quality at the lowest economic burden.

AUTO EXHAUST

The second major air pollution abatement problem concerns the reduction of pollutants produced by automobiles, trucks, and buses. These vehicular exhausts contain very large quantities of smog-producing constituents which are the major source of air pollution in certain areas. With the increasing population growth and the anticipated 3 to 4 percent a year increase in the number of automobiles on the highways, the Federal standards for auto exhausts, which will become effective with the 1968 model automobiles, will prove to be inadequate long before the end of this century.

Much progress has been made in our understanding of the types of pollutants that are emitted from automobile engines, but additional major engineering developments will be required before our technology is adequate. Although the requirements for all 1968 model cars will reduce the average level of emissions per vehicle by approximately two-thirds, we still do not really know whether the constituents from the exhaust which are largely responsible for smog production will be eliminated. It is believed that only a few of the constituents of the exhaust are the primary cause of the difficulty, while many of the other compounds present are relatively inactive. If abatement of automotive exhaust pollution is to be fully achieved, an overall systems approach should be employed which would include not only study of the fuel, but also of the engine and the exhaust system. The development of an optimum design for the automotive system involves many new techniques that have not as yet been developed. Many new engineering developments will doubtless be required before a better economic solution to the problem becomes available.

A number of different approaches to the automotive exhaust problem have been proposed and should be investigated. These include variations in fuel composition, radical changes in engine design, use of catalytic and noncatalytic afterburners, and many similar avenues.

OTHER AIR POLLUTANTS

The pollutants I have discussed are receiving primary attention at the present time. Moreover, many other materials entering the atmosphere as a result of industrial operations may require abatement action soon. These pollutants include: oxides of nitrogen and carbon; trace metallic substances and compounds from combustion of fossil fuels and metallurgical operations; polynuclear hydrocarbons in waste combustion gases; fluorides from fertilizer plants; miscellaneous dusts from mining and industrial operations; and obnoxious odors. Unfortunately, methods for removing some of these industrial wastes are unknown, while for others, studies on engineering technology are just starting. Of the pollutants specifically mentioned, oxides of nitrogen are of special importance at present because they participate in the photochemical smog-formation reaction. Further, on a very long-range basis, even the increase in concentration of carbon dioxide in the atmosphere may need to be controlled if a major change in the earth's weather pattern is to be avoided.

ACID MINE WATER POLLUTION

Acid mine water drainage is an important source of pollution for which no universally satisfactory engineering solution has yet been devised. Some scientific information has been acquired with respect to the method of acid formation in mine atmospheres and a number of engineering solutions have been proposed. Unfortunately, none of these proposed solutions has proved completely satisfactory under field conditions.

Both active and abandoned mines are potential sources of pollutants which can effectively ruin the quality of nearby water supplies. This is a particularly serious problem in the Appalachian coal fields where it has been found impossible to successfully seal off many abandoned mines. Much additional development work will be required before this problem will be resolved. It is clear that the development of adequate technology will be extremely difficult.

In cooperation with other agencies in Interior, (Geological Survey, Bureau of Sport Fisheries and Wildlife, Office of Saline Water, and the recently transferred Federal Water Pollution Control Administration), the Bureau of Mines is directing its engineering knowledge to demonstrating the effectiveness and cost of known methods for acid mine drainage control. At the same time, research and experimentation are being conducted on the causative factors for acid water formation in old abandoned mines, currently operating mines, and future mining operations. Methods investigated include new air-sealing techniques, purification by reverse osmosis, neutralization and chemical reactions, in the hope of finding ways to prevent or abate this kind of stream pollution.

As far back as 1924, the Bureau of Mines recognized a need for research in this area and started one of the first programs in the United States designed to develop fundamental information on the formation of acid in coal mines. In 1933 our people participated in an extensive mine sealing program initiated by the Federal Government as a Works Progress Administration and Civil Works Administration project. However, Federal support and interest in the problem waned, and a continuous research effort directed to an acceptable solution became impossible. Now that the public has become more aware of the needs for water quantity and quality—water for industrial and domestic consumption and for recreational aesthetic purposes has made the problem one of national concern—and support for necessary research has therefore been manifested.

The problem of acid mine water stems from both past and current methods of mining and from subsequent water drainage in geologic settings conducive to acid formation. Any mine may be a source of acid water, but the problem is concentrated in the eastern coal mining regions. Acid mine drainage may be classified as originating from three major sources: (1) deep mines, (2) strip mines, and (3) refuse piles. Deep mines may be further classified as below drainage and above drainage. The immediate problem centers on strip mines and abandoned mines above drainage level.

We know enough today to prevent acid mine water drainage from so-called open pit mines. The same is true for abandoned strip mines if provisions are made for proper reclamation, recontouring and water diversion. The problem is essentially one of cost and not technology.

Deep mines present a different story, because most of the acid draining into streams comes from abandoned underground mines above drainage. Present technology is inadequate to correct this situation. This is worthy of emphasis, for

it is a common misconception that strip mines are the chief offenders in this matter. They are not; they contribute only an estimated 10 to 25 percent of the present acid water volume. There are an estimated 8,000 abandoned underground mines with a surface area involving in the neighborhood of about 8,000 square miles. Any rehabilitation effort will therefore require a massive effort.

The Bureau's acid mine water program is directed to investigation of the available technology and demonstration of its effectiveness and the economics involved in its application to the immediate problems. This is being done through cooperation with Federal and State agencies by active demonstration projects on selected drainage areas where acid water pollution is a major problem. The program includes premonitoring conditions at the site, construction of remedial measures and post monitoring to determine effectiveness of the installed remedies.

To guide future action, we also are engaged in research to arrive at a better understanding of the principles involved. Our research includes a limited amount of laboratory investigations on the physical, chemical and bacteriological actions involved in acid water formation in mines and a field investigation (under carefully montored conditions) of special sealing techniques related to mine conditions. This should serve to resolve much of the controversy surrounding the effectiveness and value of mine sealing.

The present research effort is not adequate, relative to the seriousness of the problem and the time in which we should obtain a solution. Expanded research in the following areas is necessary:

1. Mine hydrology, drainage and pumping research that will provide a guide to engineered designing of mine systems that would prevent formation of acid mine water.
2. Techniques of eliminating or controlling ground subsidence so as to eliminate surface fractures which permit water entry.
3. Discovery or development of an applied, multipurpose coating that would provide a sealant for underground mine surface areas that would also be a dust inhibitor and have ground support capability.
4. Develop the criteria for methods to divert, contain or direct underground water flow to eliminate inflow to mine openings.
5. Continue and expand laboratory and field investigations on the formation of acid mine water.
6. Development of improved and new mining systems to minimize acid water formation.

SOLID WASTES

The disposal, control, and reclamation of waste products resulting from the extraction, processing, and utilization of mineral substances are important technologic and economic factors in the effective conservation of mineral resources. The Bureau of Mines has for many years approached the problem of minimizing or utilizing waste from the standpoint of conservation. Specifically, it has concentrated on areas where improved recovery systems would reduce mineral losses and, incidentally, reduce the volume of the products finally discarded, and has endeavored to develop methods to recover valuable metals and minerals from various types of waste.

A major aspect of our research program on mining methods is the development of mining systems that minimize minerals waste and, wherever possible, utilize waste to fill and support mine openings. In this way, with proper planning in advance of mining, operators can minimize the wastes that need to be disposed of and can avoid the restoration work that is so often required at existing operations.

The economic utilization of certain types of metallic scrap, such as automobile bodies, poses a problem which is becoming acute. Changes in the technology of iron- and steel-making have made this type of scrap less desirable for reuse than it formerly was. Approximately 6 million automobiles were scrapped last year and approximately 20 percent of these joined the 25 to 40 million old automobiles rusting away in auto graveyards, dumps, vacant lots and roadsides. The Bureau is concentrating much of its research in the field of solid waste recovery to the development of the new technology necessary to allow the economic reuse of the millions of tons of ferrous and nonferrous metals contained in these old automobiles.

One Bureau-developed process, which has been successfully tested on a small scale, and which will soon be demonstrated in a large plant, will utilize both mining wastes and automobile scrap to make a high-grade iron ore for the use of industry. In this process, non-magnetic taconite, and abundant, presently use-

less iron mineral is treated with low-grade iron and steel scrap under conditions which result in the conversion of the iron content of both materials to magnetic iron oxide which can be concentrated to high-grade iron ore by presently employed technology. Other research is devoted to the development of economic methods for removing the impurities from low-grade scrap such as that from automobile bodies, refrigerators, stoves, and washing machines, so that the metal content can be reused by industry.

The municipal wastes that are discarded each year contain approximately 6 million tons of metal, mostly iron. Most of this metal is buried in land fill and thus permanently removed from the economic cycle. The five million tons of iron in tin cans alone represents a serious loss to our economy. The Bureau of Mines is working on the development of new technology which will allow the recovery and reuse of these presently wasted metals, thus turning a liability into an asset.

In addition to other work being performed on recovery of metals and minerals from scrap, projects are underway to deal with other forms of solid wastes. For example, a survey is being conducted to reveal the location, magnitude, and composition of all of the major solid waste disposal dumps in the country. Samples from the major problem areas will be submitted for laboratory investigation to determine if any valuable constituents can be recovered or if bulk use for the material can be found. Promising results will be followed up in pilot plant scale and the process will be made available to industry.

SUMMARY

It has been shown that much basic scientific information on environmental pollution is available for application toward limiting the amount of air, water, and land pollutants which are a byproduct of our industrial system. However, there is a great lack of engineering technology for the successful abatement of many of the pollutants without putting an economic strain on industry and the public in general. We believe that through continued research and engineering development, it will be possible to solve the problems confronting the Nation effectively and economically. However, such solutions must balance public need against economic considerations. If cleaner air, water, and land is to be attained without disrupting the economy, increased efforts by both industry and Government will be required. The conversion of waste materials into useful products will help minimize these economic burdens. The Bureau of Mines recognizes its responsibilities in many areas of pollution abatement and will consistently work for technically and economically feasible solutions to the pollution problems which confront our Nation.

Mr. DADDARIO. Our next witness is Dr. Thomas Malone, vice president and director of research, the Travelers Insurance Cos., from the city of Hartford, in Connecticut.

We are happy to welcome you here, Dr. Malone.

I would also like to comment that Dr. Malone, as the chairman knows, is on the scientific panel which works with the full committee, and has been of great help to us on many occasions over these past several years.

We are happy to have you here, Dr. Malone, and we are waiting to hear from you.

Chairman MILLER. I would like to say he is one of the outstanding members of that panel, and has done a great deal of work.

STATEMENT OF DR. THOMAS F. MALONE, VICE PRESIDENT AND DIRECTOR OF RESEARCH, THE TRAVELERS INSURANCE COMPANIES

Dr. MALONE. Thank you very much, Mr. Daddario and Mr. Chairman. I responded with alacrity to this invitation to testify before your committee for two reasons. One is to renew an association I found to be extremely pleasant. I think our meeting last January

ith Sir Charles Snow and Don Price was the highlight of this series. 'econdly, I am persuaded that these hearings, the report of the advisory panel on which they are based, and what will follow from these earings, will constitute a significant step toward the development of a ational, well-conceived set of national policies for dealing with enironmental problems. Because of the availability of a great deal of iterature on pollution and the comprehensive listing of the issues in our report, I would restrict my comments to five points. The first wo are very general and the last three are specific.

First—a very general comment—so obvious that the only reason for bringing it up is that it is so easily and so frequently overlooked. Amidst all the discussion of technological capabilities and inadequacies, priorities, and strategies in scientific research, economic analysis of costs and benefits and institutional aspects, let us never forget that the problem we are discussing is—simply and fundamentally—a human problem. Human intolerance of dirtiness; human desire for cleanliness. Instincts so deeply ingrained in the fabric of our American culture that there is a rising chorus of voices across the country, demanding that the human mastery over energy and matter which has soiled our air and water, while bringing within reach the good things of life, now be put to work to restore some reasonable degree of cleanliness to our environment. From some firsthand experience with the grassroots human demands for clean water in Connecticut, I can assure you that they will not be denied—even at a cost that would have constituted a significant impediment a few years ago. In answer to a question raised by Congressman Miller, these costs will be borne in two ways: An increased cost for the goods and services produced by a proposal which entails control of pollution and second—as we have proposed in Connecticut—a major bond issue.

My second comment is concerned with the report of your Research Management Advisory Panel. It is a superbly succinct and perceptive document—and unerringly zeroes in on inadequacies in the technology for—

Treatment of mine drainage or nitrogen oxide emissions;
Removal of sulfur dioxide from stack gases;
Control of the effluents from automobile exhausts.

Emphasis on the need for basic and applied research is appropriate and timely and I would like to associate myself with the panel, without reservation, in their identification of the urgency and importance of the three examples cited. One might hope, however, that in the definitive report that may be presumed to follow this excellent exposition of issues for the purposes of discussion the litany of inadequacies in technology will be accompanied by a listing of those pollution abatement problems for which the technology is adequate (for example, the control of the emission of particulate matter in stack gases). Mr. Chairman, I flew across New York this morning at a distance of about 20 miles—you have done the same thing I know many times—and I couldn't even see Manhattan. This need not be. This is not a consequence of a technological inadequacy. It is the result of what your report called "artificial barriers to application" in this particular instance. There are other problems where the technology does have to be developed, and it would be a pity if any of the measures that are

available and can be used to get at some of today's problems were de layed because of emphasis on getting on with the technology neede for tomorrow's problems. There are measures that can be taken abate several kinds of pollution now—with the technology that is hand. It would be a pity if any of these measures were delayed, eve a year, because of a mistaken impression that they should be deferre until an improved technology is developed. The Panel very correctly points out, "In fact, the future pace of pollution abatement will de pend more and more on new and improved technology as the artificia barriers to application are removed." My plea is that, even as we pla imaginatively for the future, we leave no stone unturned now—in th present—to remove those "artificial barriers to application" that constitute the major problem of the 1960's in pollution abatement. A excellent case in point is the control of pollution by municipal sewag and here, in particular, I would urge that an expanded report trea more fully and more specifically with those aspects of the problem fo which the technology is at hand for successful abatement and those for which available technology makes possible only partial alleviation. The thoughtful reader of the Panel report will recognize that the reservation probably applies to the matter of storm sewers but the less informed reader might conclude that vigorous action on the municipal sewage problem should be held in abeyance while waiting for further technological development.

My remark about seeking balance between those things that we can and should do today and those steps that must be taken to anticipate conditions in the years and decades ahead brings me to my third point and the principal thrust of my prepared statement. It is the importance I attach to the application of scienific technique and technological advances to the diagnosis of the pollution problems and to the assessment of alternative courses of action as fundamental elements in the process by which a community reaches a decision on the specifics of an abatement program. I have in mind in particular the air pollution problem and the attractive prospects for combining the high-speed computer and mathematical and statistical technique in the construction of simulation models.

I pause here to remark that mastery of information handling by the use of electronic computers may turn out to be a more profound and far-reaching technological revolution than the mastery of energy and of matter over the past century or so. Of special relevance to these hearings is the conviction some of us share that the computer revolution may provide us with an important tool in air resource management. The development of simulation models thus becomes an important element in the national research strategy with which your subcommittee is concerned.

Some amplification may be desirable. First a word concerning "air resources management." It may seem like an unnecessary sophisticated way of saying "air pollution control," but it signifies much more than just "control." Air resources management recognizes the air as an abundant natural resource that, in certain areas and at certain times, is not of the desired quality. Insuring the continuing availability of air of acceptable quality requires knowledgeable management of the air resource.

Comprehensive air resource management requires an appreciation of, among other things—

The relationship between pollution sources and their effects;

The relative importance of aesthetics as compared to physically harmful effects;

The very real costs of control measures as opposed to the less tangible economic losses resulting from uncontrolled pollution; and

The intricate role of the atmosphere as a receiver and transporter of pollutants.

A simplified way to examine air resources management is to think of it as a closed system. Sources discharge pollutants into the atmosphere. The atmosphere's ability to assimilate the pollutants depends upon existing meteorological conditions. The combined effects of sources and the meteorology result in a certain air quality which may adversely affect some receptor. To achieve desired air quality requires that we control either the meteorology or pollutant sources. Because we cannot, at present, markedly change the meteorology, the only route open (short of making the receptor immune to pollutants) is to place controls on the sources. An additional problem often encountered here is that effective controls are hampered by technical and economic limitations, as well as by public acceptance of control measures.

Air resources management, therefore, requires a working knowledge of all of the elements of the air pollution system and an understanding of their interrelationships. Intelligently controlling air pollution at the preferred level requires the coordinated efforts of meteorologists, air pollution control engineers, chemists, economists, and public administrators.

Mathematical modeling of the system illustrated above offers hope for answering such questions as: What pollutants must be controlled, and to what degree? Although the task is formidable and experienced judgment must be applied in determining inputs to such a system, several of my colleagues are now at work on the problem.

Now a word about simulation modeling. When an air pollutant is injected into the lower atmosphere, its subsequent fate is determined by several factors. First, if the pollutant is a large or very heavy particle with a large settling velocity in air, it will fall out in the vicinity of the source. The pattern of deposition will depend upon wind speed and direction and on the intensity of atmospheric turbulence, but the residence time in the atmosphere for such materials will be brief.

On the other hand, if the pollutant is gaseous or very fine particulate material, it may remain airborne for extended periods of time. During this time it will be transported from its point of origin by the total motion, or trajectory, of the air in which it is embedded. At the same time, the distribution of the pollutant will be altered by turbulent mixing into adjacent volumes of air. If the pollutant is conservative—that is, not subject to alteration by chemical reaction, radioactive decay, or biological attenuation—it may be traced during its residence time in the atmosphere from knowledge of the atmospheric trajectories and of the diffusive or mixing rates of the atmosphere. If the pollu-

tant is not conservative, either in its physical properties or due to loss by deposition on the ground, vegetation, water, and so forth; these modifying effects must be included in any attempt to predict the location and concentration of such airborne materials.

Data from intensive studies of the transport and diffusion of gaseous materials in the lower atmosphere and for travel distances up to 20 to 30 miles are now available. Much less complete information is available for travel distances of the order of hundreds of miles, but some studies and data show very clearly that the reduction in concentration of a pollutant from a single source is, on the average, well approximated by mathematical equations. The equations provide the basic mathematical model for predicting the contribution of a single source to the concentration of a pollutant at any travel distance. Finally, it is important to determine the total concentration of a pollutant as a function of place and time. This concentration will generally represent the sum of contributions from a number of sources. Such a summation is straightforward once we have solved the diffusion and trajectory equations for each source. The position and source strength for each of the sources will be required for this summation. As soon as a model has been developed which predicts with reasonable accuracy present air quality levels, projections can be made of air pollution emissions for 5, 10, and 20 years in the future, based on various assumed degrees of industrial air pollution control, expected population increases, changes in transportation—for example, rail transit systems in cities and more car travel in the country—changes in fuel for home heating, conversion of power generation from fossil to nuclear fuel, and so forth. These projections may be plugged into the model to permit prediction of future air quality based on various selected assumptions consistent with long-term growth estimates over an area.

In sum, I would urge that the development and perfection of simulation models be an essential ingredient of the national research strategy. I believe it is unnecessary to belabor the point that the ogre of computers making decisions need not be feared. The simulation models on computers are tools in the hands of human decision-makers and are not to be confused with the decision-makers themselves.

My fourth point is related to the question raised with respect to the consequences of increasing the carbon dioxide content of the atmosphere and is relevant to the issue concerned with the establishment of meaningful cause-and-effect relationships in the environment when long time lapses occur—for example, 20 to 30 years. The increased carbon dioxide, in effect, keeps the long wave radiation from going out into space while allowing the short wave radiation to come in. Increasing carbon dioxide in the atmosphere, again in effect, is similar to providing an "extra blanket" around the earth. The outlines of a technical method for analysis of this problem and some preliminary results have been provided as a result of the elegant work of Dr. S. Manabe and his collaborators in the Environmental Science Services Administration. They have examined the dependence of the temperature in the atmosphere as a consequence of increased carbon dioxide. The technique is to employ a sophisticated mathematical model on a large-scale high-speed computer taking into account the complex interaction of the physical processes governing atmospheric motion. The preliminary

results suggest that the effect of the 10- to 15-percent increase in the total amount of carbon dioxide in the atmosphere during the century has been to increase the temperature in the lower atmosphere—that is, the troposphere—by about 0.2° C and to decrease the temperature in the upper atmosphere—that is, the stratosphere—by about 2° C.

The significance of this work lies not so much in the preliminary results which have been obtained but in the existence of a scientific and technological development which will permit an assessment not only of the temperature changes over the balance of this century but also of the effect of these temperature changes on worldwide weather patterns. As an aside, it may be mentioned that the efficacy of countervailing measures that might appear to be feasible and required can also be assessed by the same method. The implication of this situation is related to the volume of water contained in the masses of ice in polar regions. If the earth is warmed, the ice melts and the sea level would be raised so high that, were it to happen, we would probably have to swim home from this building this morning. I would emphasize that this is not an immediate danger. We do not have a crisis. The problem is not one for this year or next year, but neither is it one that can be left unattended for 100 years. The degree of danger which exists from the warming of the earth is something we must resolve in a matter of decades. The situation could become serious by the end of the century. We do have the tools now to ascertain the effects of increasing the carbon dioxide in the atmosphere and we should have these tools in pretty good working order by about 1975. If we haven't sharpened these tools by that time, we will have been derelict. Incidentally, I am a little more optimistic than your panel about the possibility of countervailing measures. I don't know yet what they will be, but I return to the point that we now have a means of assessing the efficiency of any countervailing measures that may be proposed to counterbalance the effects of increasing CO_2.

Mr. DADDARIO. Dr. Malone, you talk about our looking ahead to 1975 or to the end of the century and you point out that if we don't take certain steps now, we will be derelict in our duties. Should we even look beyond that? We do have available to us techniques that we can use to determine causes and effects over a long period of time. If you take these figures and extrapopolate them over this period, instead of having a 2° change, it could conceivably be 8° or 10°. What would that mean?

Dr. MALONE. Yes, sir, I agree with you completely that we should. Mankind in its present form has been around for about 40,000 years. We have a little responsibility even now to worry that far ahead, so you are absolutely right. The reason I picked the end of the century because it is rather difficult, and this is something a computer will not do for us, rather difficult for us to anticipate the changes that may result. We may be using entirely different forms of energy after the turn of the century so that the initial conditions of our problems may be changed rather markedly. In broader terms in the sense which you raise the question, yes, we can plug in different conditions and generate the consequences a thousand years down in the future.

It would probably take a computer quite a bit larger than we presently have but not so far beyond the state of technological capability

in the computer field that it couldn't be done. To make a long story short I agree with you.

The fifth and final point I wish to make this morning is intended to be responsive to the question raised by your panel, "What are the prospects for application of military-space research and development capability to sanitary engineering and environmental science?" Perhaps this question can be answered most directly by citing an actual example involving a subsidiary of one of our Connecticut aerospace companies, United Aircraft Corp. This work was done by United Technology, which is in Chairman Miller's State of California. The particular technological development was the design and fabrication of rocket casings for the solid propellant used in the strap-on boosters for the Titan III–C space system. These casings had a diameter of 120 inches and were made of Fiberglas which was very dense, very thick, very strong, very effective—and also very expensive. A young United Technology Corp. engineer, Dick Seymour, recognized that the manufacturing process could also be applied to earthbound uses. The civilian application involved was to identify a "filler" which would at once increase the rigidity of the Fiberglas casing and lower its cost. Ordinary sand turned out to be effective on both counts. The resulting product—a sample of which I hold in my hand—holds attractive promise as a material cheaper and better than traditional underground piping for the transport of water or disposal of sewage. Not only are prices competitive, even for small sizes, but for the same cost the following advantages are obtained:

Greater strength (and hence less breakage)

Greater versatility from the standpoint of ease in drilling, shaping, etc.

Smaller frictional coefficient

Greater ease of coupling of sections (which reduces labor costs).

Even more direct applications to the problems of pollution are envisioned. Preliminary design plans have been developed for an entire sewage treatment process within a long pipeline submerged under a river bed. Not only would these long subterranean pipelines with sewage treatment capabilities be economical to install, but it is believed that they would have distinct advantages in distributing the discharge of treated effluent over an extended range of the river body. Further development is obviously required, but I venture to predict that we will hear more about this particular space science "fallout" during the years ahead.

In closing, I would suggest that these hearings are a significant step toward the development of rational, well-conceived national policies to deal with environmental problems. An additional step will be a reexamination of:

The organizational structure at the Federal level along the lines recommended by the President's Science Advisory Committee in a recent report, "Effective Use of the Sea," and the National Academy of Sciences in another report, "Weather and Climate Modification—Problems and Prospects," both of which stress the fundamental unity of the environmental sciences and the need for a Federal effort of "critical" size in order to be effective.

The decisionmaking mechanisms at the local, State, and regional levels with particular attention to the decentralization of decision-

making authority to the lowest feasible organizational entity. My experience with the Connecticut Clean Water Task Force leaves me persuaded that new kinds of partnership between the Federal Government and the local government will be required. I believe that devising these organizational frameworks is a complementary step to the examination of technology.

Chairman MILLER. Mr. Chairman, unfortunately I have to go. I am sorry that I can't remain. Before I go, I want to express my gratitude to Dr. Malone for giving us this very stimulating paper here oday. I assure you that I shall read it. As a matter of fact, I intend to also give a copy to the man that I am going to meet in a few minutes because he is going to be very much interested in this subject. He is Harrison Brown.

Dr. MALONE. Oh, give my regards, Mr. Chairman.

That concludes my testimony.

Mr. DADDARIO. In reference to your last point on the bringing together of local, State, and Federal efforts so that you can coordinate the resources and do a better job, how about the manpower situation? Can we overcome the shortage within a reasonable enough period of time so that we can have effective activity at the local level?

Dr. MALONE. Yes, sir; I am optimistic that people like some of the engineers at United Aircraft, United Technology, are worrying about this. They are getting into some of these problems that they wouldn't have thought about 5 years ago. I think that we have brought together some very potent and effective groups in connection with our military space programs. Now, I can say this, the chairman has left, so I can refer to California without embarrassing him or me; we are all familiar with the systems studies that were sponsored by the State of California drawing upon this kind of competence. It is my observation that the same kind of talent which has proved so tremendously effective in our formidable space problems is eager to come to grips with some of these. I think that there is some virtue in bringing that acquired competence to bear on these matters rather than trying to develop through the traditional training programs the kind of competence we need.

In other words, there is an advantage in this transfer of training, laterally, rather than relying on a massive vertical development of the traditional skills.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. I have no questions.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. I'm curious to know what you have in mind in terms of the organization which would build, say, a large-scale atmospheric model. You have discussed a computer model of air pollution flow. Where would you see that, in the Environmental Science Services Administration?

Dr. MALONE. That is where the study I referred to was specifically done; yes, sir.

Mr. VIVIAN. Would you see the model also being handled by that agency?

Dr. MALONE. Yes; it is already there. They have models. They re the ones who made the assessment of the CO_2 content. I don't

mean it should be there and nowhere else. I think we should have som diversity. For example, there is a major laboratory in Colorado, i Boulder, Colo., operated by a consortion of universities with suppo from the National Science Foundation. They too are moving in th direction of these large models. I would even go one step further. Th kind of problem we are talking about in the CO_2 is intrinsically a international problem. We are now aiming at a concerted study o the global atmosphere in which there will be an international progra in 1972 and it will hopefully provide precisely the kind of data o a worldwide basis which is necessary to crank up these models.

Moreover, it will, hopefully, initiate a pattern of international co-operation which will be helpful in anything you might have to do t counterbalance or control the CO_2 increase.

Mr. VIVIAN. I would like to point out, as was mentioned earlier today by previous witnesses, that at present we must choose whether to pollute water or air when we deal with sulfur oxides from stack gases. They can be leached out and put into the water systems or they can be heated up and spread out into the air. We have had previous comments of the same variety relating to disposal of other solid waste. There is an important question about the interchange of types of waste. Now, what part of the Federal Government decides which portion of our environment shall accept the waste? Is this the Environmental Science Services Administration or is this some other agency?

Dr. MALONE. This was a problem I was precisely trying to point out. I don't have an answer. I don't believe everything should be encompassed into a single agency. This kind of competence is found in several places in the Federal Government. That is desirable as long as there is at least one entity which is capable of mounting the rather large efforts that are needed so that things don't fall between the cracks.

Mr. DADDARIO. Dr. Hibbard, while you are here why don't you comment on that?

Dr. HIBBARD. I guess I would say I wouldn't know where one would go for this overall decision. I think that this question needs attention and actually isn't solved. I'm afraid I can't contribute much to that.

Mr. VIVIAN. Where are the natural places in Government today where such activity would gravitate?

Dr. MALONE. I would say Interior, certainly, because they have so many of these programs. Commerce because they have the Weather Bureau, the Coast and Geodetic, and the Central Radio Propagation Laboratory. Agriculture certainly has many of these problems in it, and HEW is quite involved in this. The National Science Foundation is involved in a somewhat different way. It is not mission oriented in the way some of these other agencies are. The Atomic Energy Commission has concern with some of these. The Defense Department, the Corps of Engineers. Well, you could go on and list this and about the only thing comes out of it is that you are persuaded it is a very complex problem.

Mr. VIVIAN. The Weather Bureau is working on a massive atmospheric model which is probably more complex than the smaller sized one needed for handling pollution problems. Wouldn't any air pollution model automatically run off of the atmospheric model that is use for weather prediction?

Dr. MALONE. Let me answer that in two ways.

First, certain kinds of pollution problem, yes; almost identically the same kind of model. The kind of simulation problem we are thinking about in Connecticut is not necessarily the same model, but I would take issue with the thought that it would be a simpler problem. The proper mathematical model for a single cloud, as far as its demands upon computer speeds and storage, is about the same as the global circulation in its demands on computer speed and storage capacity. On the other hand, you are quite correct in that the habit of thinking, the way of handling these problems are characterized by a certain unity even though they are different models and different parameters.

Mr. VIVIAN. I am curious to know if the variety of Government agencies which handle pollution of all forms have a coordinating unit—a single coordinating center which deals with the whole subject of pollution.

Dr. MALONE. I am sorry, I don't know.

Mr. VIVIAN. I didn't expect you to know the answer to that question but perhaps someone else here will know.

Dr. MALONE. There is a PSAC Panel.

Mr. VIVIAN. That would not normally deal with this.

Mr. DADDARIO. Your questions are extremely important, Mr. Vivian, and I think we ought to keep them in mind when other witnesses who should be able to give us an answer come before us.

Mr. VIVIAN. I do have one brief observation to make and that is on the estimated cost of auto antipollution devices. You quoted a figure of $500 million, I believe, Mr. Chairman. This represents approximately one-tenth of 1 percent of our gross national product which does not seem very onerous. An estimated cost of water and sewer pollution abatement activities for municipal purposes shows that we have about another tenth of a percent each in the operation of plants and in capital investment which suggests that our total figure in pollution reduction is not a very large figure. A few tenths of a percent of the gross national product is a pretty small figure—so we have a long way to go.

Dr. MALONE. You will find an article in Fortune magazine in 1963 which takes very much this point of view. I think you will find it very interesting reading. They address themselves specifically to this question. Can we afford air pollution? They answer very much in the terms you have now.

Mr. DADDARIO. Mr. Fulton, we are happy to have you here.

Mr. FULTON. I come from Pittsburgh, Pa., where we are very interested in pollution and the methods being used to clean it up.

I liked the comment on page 3 of your statement that removing those artificial barriers to the application of pollution control devices constitutes the maior problem of the 1960's in the field of pollution abatement. I think that that is an excellent statement, and with the chairman's permission I would like to have you expand your ideas on it because I believe that costs are not the only barriers. There are many other barriers and we should be looking at the methods of implementing controls.

One final point is this: Pollution has been looked at as a problem of negligence and as an effect of a lack of knowledge. But even if we obtain the knowledge and the method of handling manmade pollution, it brings to mind that in the middle of the 19th century there was a volcano that erupted and polluted the atmosphere so that in the Northern Hemisphere it snowed in July and August. This is a climate change that would have immense strategic bearing. For example, the crops all failed in a certain band. Although there was no warning of this, it caused a complete crop failure. On the strategic level I think some thought should be given to what could happen if certain bands of the high atmosphere were polluted.

We in Pittsburgh have met the problem of smoke pollution I think as well as any city in the country. The cleanup of Pittsburgh's air was achieved by a monumental bootstrap operation. It called for an unstinting cooperative effort by every element of the community. The limitation forbade all outside open fires, placed limits on the quality of the fuel sold, and generally put the emission of all types of airborne gases, vapors, and fumes, under regulatory control. For one city that was a tremendous change.

That was one of Mr. Vivian's points. It was a costly change for every person there, but it has been the greatest benefit that Pittsburgh ever had. I can say from our own experience that we in our area think that municipal and private expense as well as corporate expense was tremendously worthwhile.

I want to congratulate you both on your excellent statements.

Mr. DADDARIO. Thank you, Mr. Fulton.

Mr. Wydler?

Mr. WYDLER. I have no questions.

Thank you.

Mr. DADDARIO. Dr. Malone, again I wish to thank you and Dr. Hibbard and his colleagues.

It has been a very helpful morning for the committee.

(The biographical statement of Dr. Thomas F. Malone follows:)

BIOGRAPHICAL STATEMENT OF DR. THOMAS F. MALONE

Thomas F. Malone is Vice President and Director of Research for The Travelers Insurance Companies, Hartford, Connecticut. He also serves as: Chairman, Connecticut Clean Water Task Force (composed of 100 interested citizens from all walks of life in Connecticut who responded to a request from Governor Dempsey to recommend an action program to assure clean water for Connecticut); chairman, Committee on Atmospheric Sciences, National Academy of Sciences; chairman, U.S. National Commission for UNESCO; Secretary General, Committee on Atmospheric Sciences, International Council of Scientific Unions and International Union of Geodesy and Geophysics; member, Committee on Water, National Academy of Sciences; member, Connecticut Research Commission.

In the recent past, he has served as: Member of the Advisory Committee on Air Pollution to the Department of Health, Education and Welfare, member of the Special Commission on Weather and Climate Modification to the National Science Foundation; President of the American Geophysical Union; president of the American Meteorological Society.

A graduate in engineering from the South Dakota School of Mines and Technology, Dr. Malone received his Doctorate of Science in Meteorology from MIT in 1946. He spent fifteen years in research and teaching in the Department of Meteorology at MIT and was the Editor of The Compendium of Meteorology published by the American Meteorological Society. A fellow of the American Association for the Advancement of Science, the American Geophysical Union and the American Meteorological Society, Dr. Malone was the recipient of the Robert A. Losey Award of the Institute of Aerospace Sciences in 1960 and the Charles Franklin Brooks Award of the American Meteorological Society in 1963.

Mr. DADDARIO. This committee will adjourn until Tuesday next at 10 o'clock at the same place.

(Whereupon, at 12:05 a.m., the subcommittee was adjourned to reconvene at 10 a.m., Tuesday, August 9, 1966.)

THE ADEQUACY OF TECHNOLOGY FOR POLLUTION ABATEMENT

TUESDAY, AUGUST 9, 1966

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The committee met, pursuant to adjournment, at 10:10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our first witnesses this morning are Mr. Gammelgard and Dr. Eckardt.

Mr. Gammelgard is director of the Committee for Air and Water Conservation for the American Petroleum Institute and Dr. Eckardt is also with the American Petroleum Institute. If you two gentleman will come forward, please.

We are very happy to have you here.

Mr. GAMMELGARD. Thank you, sir.

Mr. DADDARIO. If you would, please, go right into your statement.

STATEMENT OF P. N. GAMMELGARD, DIRECTOR OF COMMITTEE FOR AIR AND WATER CONSERVATION, AMERICAN PETROLEUM INSTITUTE

Mr. GAMMELGARD. My name is Nick Gammelgard and with me on my right is Dr. Eckardt. My background is engineering and administration and Dr. Eckardt's background is medicine and toxicology.

We appreciate the opportunity to discuss with you the adequacy of science and technology presently available for pollution abatement, and to consider the future course of research and development, with particular application to the oil industry.

As background for our presentation, I might note that API and its supporting members have been engaged in research and practice in water conservation for nearly 40 years, and in air conservation research and practice for more than 10 years.

During this period, the oil industry has sponsored a variety of biological and engineering studies seeking answers to our pollution problems. One project that might interest you is our "Manual on Disposal of Refinery Wastes" which I have here with me. This is a continuing project, begun in the 1920's, and it now represents the cur-

rent state of conservation technology in oil refining operations. The manual is now in six volumes: two deal with water pollution, one with chemical wastes, two with air pollution, and the most recently issued deals with solid waste disposal. Literally tens of thousands of man-hours of effort have been devoted to the preparation and the revising of this manual. Altogether the manual consists of 546 pages.

(A listing of the chapter headings and contents follows:)

CHAPTER HEADINGS OF AMERICA'S PETROLEUM INSTITUTE'S "MANUAL ON DISPOSAL OF REFINERY WASTES" (SIX VOLUMES, 546 PAGES)

VOLUME I. WASTE WATER CONTAINING OIL (SEVENTH EDITION, 1963, 104 PAGES)

Chapter 1. General Considerations of Contamination of Water by Oil.
Chapter 2. Gravity-Type Waste-Water Separators.
Chapter 3. Secondary Treatment of Refinery Effluent.
Chapter 4. Treatment of Waste Emulsion.
Chapter 5. Disposal of Ballast Water and Tank-Cleaning Emulsion From Tankers and Barges.
Chapter 6. Measurement of Waste-Water Flow.
Chapter 7. Dispersion of Refinery Effluents in Receiving Waters.
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VOLUME II. WASTE GASES AND PARTICULATE MATTER (FIFTH EDITION, 1957)

Chapter 1. Possible Pollution of the Atmosphere by Gases and Particulate Matter.
Chapter 2. Classification and Sources of Contaminating Gases and Particulate Matter.
Chapter 3. Properties of Contaminating Gases and Particulate Matter.
Chapter 4. Recommended Practices.
Chapter 5. Collection and Treatment of Pollution Gases and Particulate Matter.
Chapter 6. Disposal of Particulate Matter.
Chapter 7. Combustion of Gases in Furnaces.
Chapter 8. Smokeless Flares.
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VOLUME III. CHEMICAL WASTES (FOURTH EDITION, 1960, 93 PAGES)

Chapter 1. Properties of Chemical Waste Waters.
Chapter 2. Sources of Chemical Wastes.
Chapter 3. Effect of Chemical Wastes on Natural Waters.
Chapter 4. Waste Control.
Chapter 5. Control of Waste Streams by Stripping.
Chapter 6. Control of Phenolic Waste Water by Solvent Extraction.
Chapter 7. Processes and Methods of Treating Waste Waters Biologically.
Chapter 8. Processes and Methods of Treating Waste Waters Chemically.
Chapter 9. Recommended Handling of Specific Refinery Wastes.
Chapter 10. Process Summaries.
Supplements. Petrochemical Wastes (to be included as a new chapter of volume III, when it is reprinted).
Biological Factors of Pollution as Affecting Receiving Waters (a section of the API "Manual on Disposal of Refinery Wastes").

VOLUME IV. SAMPLING AND ANALYSIS OF WASTE WATER (97 PAGES)

Contents:

Collection and Preservation of Samples.
Spot Samplers and Their Use.
Automatic Compositing Samplers.
Absolute Density of Waste Water: Hydrometer Method.
Absolute Viscosity of Waste Water: Glass Capillary Method.
Acidity and Basicity of Refinery Waste Water.
pH: Glass Electrode Method.
Hardness.
Solids: Total, Dissolved, Suspended, Settleable.
Total and Dissolved Sulfides: Methylene Blue Colorimetric Method.
Dissolved Hydrogen Sulfide: pH Method.
Sulfides and Mercaptans: Electrometric Titration.
Total Sulfur: Bromine Oxidation Gravimetric Method.
Alkyl Phenols: Colorimetric Nitrosophenol Method.
Phenolic Materials: 4-Aminoantipyrine Method.
Phenolic Materials: Infrared Spectrometric Method.
Color.
Turbidity of Waste Waters: Jackson Candle Turbidimeter Method.
Odor: Threshold Odor Number and Odor Quality.
Dissolved Oxygen in Effluent: Manganous Reduction Method.
Dissolved Oxygen: Alkaline Iodide-Azide Method.
Biochemical Oxygen Demand: U.S. Mean Dilution Water Method.
Chemical Oxygen Demand: Dichromate Reflux Method.
Immediate Oxygen Demand.
Immediate Chlorine Demand.
Volatile and Nonvolatile Oily Material: Reflux Distillation-Extraction Method.
Nonvolatile Oily Material: Flocculation-Extraction U-Tube Method.
Volatile and Nonvolatile Oily Material: Infrared Spectrometric Method.
Susceptibility to Oil Separation: STS Number.
Ammonia Nitrogen: Nessler Reagent Method.
Organic Nitrogen Kjeldahl Method.
Clorides.
Fluorides.
Iron.
Manganese.
Total Lead in Water and Water-Bottom Deposits.

VOLUME V. SAMPLING AND ANALYSIS OF WASTE GASES AND PARTICULATE MATTER (72 PAGES)

Contents:

Collection of Samples.
Hydrocarbon Evaporation Losses From Oil and Water Separation Processes.
Measurement of Gas Flow.
Particulate Matter: Filtration Method.
Particulate Matter: Impingement Method.
Particulate Matter: Impaction Method.
Aldehydes: Bisulfite Absorption Method.
Ammonia: Kjeldahl and Nessler Reagent Methods.
Carbon Monoxide and Carbon Dioxide: Absorption-Combustion Method.
Hydrogen Cyanide and Cyanogen: Colorimetric Method.
Hydrocarbons in the Atmosphere: Mass Spectrometer Freeze-Out Method.
Hydrogen Chloride: Turbidimetric Method.
Inorganic Fluorides: Absorption-Distillation Method.
Nitrogen Oxides in Gaseous Combustion Products: Phenoldisulfonic Acid Method.
Hydrogen Sulfide: Tutweiler Apparatus Method.
Hydrogen Sulfide: Ammoniacal Cadmium Chloride Method.
Hydrogen Sulfide and Mercaptans: Electrometric Titration Method.
Total Sulfur Oxides: Acidimetric Method.
Sulfur Dioxide and Sulfur Trioxide: Acidimetric Method.
Sulfur Dioxide in the Atmosphere: Disulfitomercurate Method.

VOLUME VI. SOLID WASTES (FIRST EDITION, 1963, 49 PAGES)

Chapter 1. Solid Wastes in Refinery Operations.
Chapter 2. Solids in Natural Waters.
Chapter 3. Sludges Containing Water and Solids.
Chapter 4. Sludges Containing Oil and Solids.
Chapter 5. Sludges Containing Oil, Water, and Solids.
Chapter 6. Biological Treatment and Sanitary Sewage Sludges.
Chapter 7. Miscellaneous Solid Wastes.
Chapter 8. Dewatering and Deoiling.
Chapter 9. Biological Decomposition of Solid Wastes.
Chapter 10. Incineration.
Chapter 11. Land Disposal.
Chapter 12. Miscellaneous Disposal Procedures.
Chapter 13. Solid Waste Disposal Plants.
Index (pages 50 and 51).

I have also brought a bibliography of publications (this bibliography may be found in the committee file) which have resulted from research conducted largely by oil company technologists on the disposal of water-borne wastes. This research covers the years 1929 through 1962. I thought you might wish to include this bibliography in the record.

During the little more than 10 years that have elapsed since the Federal Clean Air Act was passed in 1955, industry expenditures on conservation research and pollution control equipment exceeded $220 million for air, and exceeded $150 million for water.

During 1966, the oil industry increased its budget substantially, and will spend more than $43 million on air conservation alone. These are investment figures only; we do not have figures on operating costs, but they have been substantial.

It is true, as your panel's report states, that technical and economic limitations still face the Nation in its efforts to abate pollution. I would like to tell you about some of these limitations from the standpoint of the oil industry.

As far as water pollution abatement at oil industry facilities is concerned, technology and procedures are well advanced. Progress here will result more from steady capital investment than from research.

In the producing area, the industry's record of brine disposal has been one of encouraging progress. This progress has been made as a result of long-term cooperative efforts between oil producers and State regulatory agencies. This is despite the fact that oil producers in the United States must dispose of 24 million barrels of brine every day. Put another way, an average of three barrels of brine must be disposed of for every barrel of oil drawn from the ground.

While some areas of the brine disposal problem are still not satisfactorily solved, particularly those involving marginally profitable producers, our problem today is mainly economic rather than technical. We were quite proud to hear Secretary Udall's statement, before the National Petroleum Council last month, that in the area of water conservation, the petroleum industry "still has a way to go, but needs only to press to a conclusion the excellent programs * * * under way."

And at this point, I would like to call your attention to an article that Senator Muskie had entered in last Friday's Congressional Record

in which it was noted that the Humble Oil & Refining Co.'s Baytown refinery received the Honor Roll Award from the Izaak Walton League for its outstanding air and water pollution control programs. The Baytown, Tex., refinery is one of the Nation's largest refineries.

In the area of air pollution, however, our problem is more complex, for science and technology are not yet available to help us solve all of our problems.

While there is considerable agreement on criteria for water quality, what constitutes reasonable criteria for air quality has not yet been determined.

In fact, sometimes I think we are coming up with solutions to problems that have not yet been defined.

We believe there is a vast amount of research that must be conducted before we can reach a sound understanding of the cause-and-effect relationship between air pollutants and their effects—an understanding which must be reached if we are to provide the basis for good pollution control legislation.

To help develop some of this understanding, API has budgeted some $2 million for 29 air conservation research projects that will be sponsored at various industrial laboratories, universities, engineering firms, and Government agencies in 1966.

To save your time, I will file a separate list detailing the 29 API projects, covering the broad areas of technological and medical research.

(The list of API projects follows:)

SUMMARY OF 1966 AIR CONSERVATION RESEARCH PROJECTS OF THE AMERICAN PETROLEUM INSTITUTE

1. This study would determine the feasibility, cost, and effectiveness of an API-proposed fixed-instrument air monitoring system that would alert a population once sulfur oxide and particulate matter exceed certain levels. Contractor: Jackson & Moreland.

2. This study will evaluate air monitoring methods and meteorological forecasting by providing for actual air monitoring, using mobile equipment, in New York City. Data will be compared with data from fixed instruments. Project S–1. Contractor: New York University.

3. A study of oil companies, associated contractors, and petroleum-oriented development companies to learn past and present expenditures on research and development, facilities, etc. to reduce the sulfur content of fuels. Project S–2. Contractor: The Pace Company.

4. A study to learn the probable cost of reducing the sulfur content of residual oil supplied to our Eastern seaboard from the Caribbean area. Project S–3. Contractor: Bechtel Corporation.

5. This study will evaluate the present "state of the art" on methods to remove sulfur dioxide from stack gases. When this phase of the study is completed, a task force will attempt to cooperate with the Bureau of Mines and the coal industry on further research. Project S–4.

6. & 7. Two studies that will determine the possible chronic and/or acute health effects of sulfur oxides and particulates by correlating clincal data from health agencies with changing levels of these pollutants. These studies will require acceptable air monitoring systems. Projects S–5 and S–8.

8. A study to determine the possible chronic long-term effects of low dosages of air pollution by exposing test animals to controlled atmospheres. A cooperative project wtih five other organizations. Project S–6. Contractor: Industrial Hygiene Foundation of America.

9. The project will study the effect on laboratory animals of sulfur dioxide, sulfur dioxide plus particulates, nitrogen dioxide, and nitrogen dioxide plus particulates, both singly and in combination. The purpose is to determine long-

term, low-dose health effects, and the safe limits of air pollution from products of fuel combustion. Project S–7. Contractor: University of North Carolina.

10. A study of the composition of the stack effluents that result when different types of coal and oil are burned. Special attention will be paid to sulfur compounds and particulate matter. A cooperative project involving API, Public Health Service, and Bituminous Coal Research. Project S–9.

11. To monitor lead levels in the ambient air and in the blood and urine of man, to permit early detection if any tendency toward lead accumulation occurs. A possible continuation of the "Tri-City" study. Project L–1.

12. This project will conduct medical studies that may determine (a) subclinical effects of lead in man, or (b) the effects of lead, if any, on well-established clinical conditions, e.g., respiratory diseases. Project L–2.

13. A study directed toward understanding the relationship between bone lead and blood lead. Project L–4.

14. A study that will attempt to determine the relationship of bone lead to the total of lead in the body, and to determine how this relationship has changed with time. Project L–3.

15. This study will determine lead concentrations in soil and vegetation at known distances from highways, to assess the significance of lead fall-out adjacent to highways. Project L–5. Contractor: Rutgers University.

16. A study to determine the lowest level of atmospheric lead that will produce a measurable change in blood lead. In cooperation with the Public Health Service, du Pont, Ethyl Corporation, and the Lead Industries Association. Project L–6. Contractor: Kettering Laboratory, University of Cincinnati.

17. This study will determine what effect, if any, on evaporative and exhaust emissions of automobiles would be brought about by varying fuel composition and volatility, and by blending gasoline with and without lead. An effort will be made to determine the effect on the output of nitrogen oxides and carbon monoxide resulting from variations in gasoline formulas. Project VL–1. Contractor: Bureau of Mines.

18. Using newly available techniques for evaluating the biological effects of lead, this study will involve long-term exposures of mice, rats, rabbits, dogs, and monkeys to lead acetate by feeding and other routes of administration. Special techniques employed will include electron microscopy; and enzyme, behavorial, and radiotracer studies. Project L–8. Contractor: Hazleton Laboratories, Inc.

19. Case studies of representative refineries throughout the United States to determine the incremental cost of making gasoline without lead alkyls. Project LV–9. Contractor: Bonner and Moore.

20. A study to compare the lead burdens of laboratory animals exposed to heavy concentrations of automotive emissions with others not exposed to these concentrations. Project L–10. Contractor: Wayne State University.

21. This study has two purposes: (a) to compare the present total environment—land, air, and water—with the ancient environment by using the isotopic character of lead as an environmental tracer; and (b) to discover the relative importance of various possible sources of lead, and to better understand the mechanisms of lead transfer. Project L–11.

22. A study to determine the effect of volatility changes on the performance of automobiles subjected to a wide range of temperatures. Project V–4. Contractor: Esso Research and Engineering Company.

23. To study methods that industry can use to measure evaporation losses from fuel tanks and carburetors. Project CR–1. Sponsor: Coordinating Research Council of the Society of Automotive Engineers and the API.

24. To determine how variables in fuels and vehicles affect automotive exhaust composition. Project CR–2. Sponsor: CRC.

25. To develop techniques for analyzing exhaust emission composition. A cooperative project with the Automobile Manufacturers Association and others. Project CR–3. Contractor: Bureau of Mines.

26. To develop instruments that will provide meaningful measurement of the various hydrocarbons in automotive engine exhaust. Project CR–4. Sponsor: CRC.

27. This study will attempt to identify the components causing odor and eye irritations associated with diesel emissions, and to relate these components to engine-type and operating conditions. Project CR–5. Contractor: Scott Research Laboratories, Inc.

28. A study of the toxicity of aromatic hydrocarbons in the lung, with particular emphasis on the relationship of the physical characteristics of particles to carcinogenesis. Project EH–1. Contractor: The Chicago Medical School.

29. A study that will analyze ambient air samples of hydrocarbons covering a wide molecular range, and will compare them to similar compounds from known sources—including automotive exhausts. The samples will also be studied to determine the rate of hydrocarbon disappearance when exposed to irridiation. Project BR–1. Contractor: University of California (Riverside).

Mr. GAMMELGARD. Permit me, however, to review some of these projects so that you will understand the oil industry's views as to research and technology limitations that beset us today.

We are presently concerned with two main areas. The first of these is sulfur oxide pollution resulting from the burning of some heavy or residual fuels. I should point out that, through advanced technology, the oil industry is now producing "almost-sulfur-free gas, gasolines, lubricating oils, and light fuel oils that constitute the bulk of the products of the oil and gas industry," as was stated the other day at these hearings by Arthur Stern, Assistant Chief of HEW's Division of Air Pollution.

However, there has been no comparable success in our quest for a technically feasible yet economic way to reduce the sulfur content of high sulful residual oil used in industrial plants, power stations, and other large facilities.

A considerable amount of research is being carried on by individual oil companies to devise practical ways to attack the sulfur oxides problem.

Since economics is a constant consideration in this sulfur matter, the API is currently sponsoring a study by the Bechtel Corp. to determine the feasibility and cost of reducing the sulfur content of residual oil that is supplied to our eastern seaboard from the Caribbean area refineries, such as those in Venezuela.

Another API-sponsored study is being conducted by the Pace Co. of Houston. It will provide factual information on how much past and present effort the oil industry has made to reduce the sulfur content of its products.

Since researchers have encountered difficulties while trying to reduce the sulfur content of high-sulfur residual oil, we are exploring another possibility. API is now conducting a state-of-the-art study regarding removal of sulfur oxides from the stack gases that result when fuel is burned. When this exloratory data is assembled, we will attempt to cooperate with other groups on further research.

Mr. DADDARIO. What other groups do you have in mind? The coal industry?

Mr. GAMMELGARD. Yes, we are thinking of coal people. The Bureau of Mines have a process that they are currently researching with PHS funds. Others that are interested in this process will contribute in money and manpower.

Mr. DADDARIO. Do you sense a desire to cooperate in this area with these other people?

Mr. GAMMELGARD. Yes, sir. I think there are about four processes now that look like like they might have promise but the economics yet do not look very good and research should be done in several of them to find out if something can be brought forth that can have good economics.

Mr. CONABLE. How about steel, are they also interested in this field?

Mr. GAMMELGARD. I would think that primarily interest would come from the fossil fuel suppliers and main users—big industrial users. Steel does, of course, come under that category. They might wish to contribute something.

The second area of inadequacy to which increased attention is being paid by the oil industry is that of emissions from gasoline engines.

A $480,000 technical project that we are sponsoring is underway at the Bartlesville, Okla., laboratories of the Bureau of Mines.

Mr. DADDARIO. What is the contribution of the Bureau of Mines in this particular project?

Mr. GAMMELGARD. As I understand it, Mr. Chairman, our money is essentially financing this project including the payment of salary of Bureau of Mines personnel at their salary rates plus some of their benefits. But things like the buildings and facilities that will be used in this project that are the property of the Bureau of Mines—we are not paying anything for this. This is sort of a contribution in kind that they are making. We would have been perfectly happy if the Bureau of Mines would have had half of the money to contribute as their share of it. We weren't anxious to pay for the entire project. There was no attempt on our part by paying the entire tab to maybe try to control what comes out of this project. In fact, we would be happy to put in a minor share of the money if it would make the Government happy.

Mr. DADDARIO. I am not insinuating that it might be a directed study because you are paying a major share of it. It seems to me that as you have already said, it is the size of the program that is important.

I was trying to determine how much more money over and above the $480,000 will be provided by other sources. I am certain your study would be objective. Otherwise, I don't know how we could head it under the term of research.

Mr. GAMMELGARD. That is correct. I agree with you. I think there are some that don't share your viewpoint, however.

Mr. DADDARIO. I assure you there is no bias.

Mr. MOSHER. Mr. Chairman, what is this criticism? You have implied that this study has been criticized. Who is criticizing it?

Mr. GAMMELGARD. The Senate Committee on Public Works, in its report accompanying S. 3112, made the comment that this project raised the issue of the propriety, I believe, of industry financed research in Government facilities where the public welfare was involved or the common good. It is pretty difficult to get away from the common good not being involved in a pollution problem so this in our opinion would mean any project in the air and water pollution fields would come under the public welfare or domain. The committee recommended projects such as ours with the Bureau of Mines should be brought to the Congress some 90 days before they might be signed up as an on-going project for review. In my opinion, a procedure like that would effectively build a wall between Government and industry work where industry paid for research in a Government agency. I can see nothing wrong in a case like this where both parties think and believe that this is an excellent project. Budget considerations in our industry association in the past have limited us to projects that will

start about 2 years hence. Last November we cut the red tape in API and approved a budget in just 48 hours of several million dollars.

This is unusual for API and we are going to require about 6 months leadtime for approval of next year's projects.

We recognize that research projects may come up on short notice and you shouldn't have to wait for an administrative budget procedure that doesn't get the project off the ground for 18 or 24 months. I think in this case the Bureau of Mines could probably dig up some money a year or two from now for this project and make possible new discoveries and proceed along such new avenues as this research goes forward. We will be glad to come up with manpower and money to explore promising avenues in this field.

Mr. MOSHER. Mr. Chairman, I don't quarrel at all with Mr. Gammelgard's point of view as just expressed but I assume this issue of propriety will be considered in our report.

Mr. DADDARIO. Yes; I don't think there is any question about that, Mr. Mosher. We have looked into the standards established over the course of time by the Bureau of Mines in conducting programs of research such as this, and the results have indicated that it has been an objective and proper type of a cooperative venture.

Mr. GAMMELGARD. Very much so.

Mr. DADDARIO. I do think we need to look at it and to sort of document the kind of programs that are carried out. Mr. Mosher's question to you and your explanation have added to the discussion and put us on the right road.

Mr. GAMMELGARD. Thank you, Mr. Chairman.

The purpose of this research is to determine what effect, if any, on evaporative and exhaust emissions of automobiles would be brought about by varying fuel composition and volatility, and by blending gasoline with and without lead.

At least 25 passenger cars, selected to encompass a wide range of types, will be employed in the tests. All vehicle emissions will me measured in terms of total quantity, composition, and smog-forming potential using the very best available scientific knowledge and equipment.

In the tests an effort will also be made to determine the effects of variations in gasoline formulas on the output of nitrogen oxides and carbon monoxide.

When I mentioned evaporative and exhaust emissions, I think it might be worthwhile to say that up until 1963 when positive crankcase devices were voluntarily put on new automobiles made in the United States, there were four "holes" in a car's fuel system. One is the vent in the fuel tank. You have to have a vent or you would collapse the tank when you pump the gas out of it. There is a gasoline vapor loss as "breathing" takes place in the tank.

Another one is the carburetor. After driving and then stopping your engine, the heat under the hood causes some of the gasoline that is in the bowl to evaporate into the atmosphere. There are other minor losses from the carburetor.

The third one was the crankcase vent where from 20 to 35 percent of the gasoline lost from a car took place through the road draft tube. That was sealed off and by recirculating vapors back into the intake system that loss was eliminated.

The fourth and the major one is the tailpipe of the car. Some of the hydrocarbons are not completely burned in the engine and go out the tailpipe and it is some of these hydrocarbons that mix with the oxides of nitrogen that also come out and together can form a smog problem under certain atmospheric conditions.

It is quite possible that this research will produce no better gasoline, from an air pollution standpoint, than any gasoline produced and used today. But we want to know what, if anything, can be accomplished by variations in gasoline formulas.

Chairman MILLER. You say this research will not produce a better gasoline and then you speak of the variation of gasoline formulas. Don't all of the companies vary their gasoline and doesn't each company have its own formula? At least that's what they tell us. These high-test gasolines are not all of the same formula, are they? Aren't they actually differences? If you do get a formula, will the gas companies be obligated to use it or will they continue to use the gasolines developed in their own laboratories?

Can anything be gained in the marketplace with the proper formula?

Mr. GAMMELGARD. Well, that is a pretty good-sized question you have thrown there, Mr. Miller. There are differences in gasoline, there is no question about that. In general, gasoline is a mixture of hydrocarbons that boil in the range from about 100° to 400° F. Some might chop theirs at 385° because they think that is the right end point, others may exceed 400°.

Other companies put in additives that they think are superior to other companies' additives.

Chairman MILLER. One company advertises a pure gasoline with no additives. I believe additives were introduced about 30 years ago when we began to put ethyl in the tank. This particular company claims that there will not be any sludge or carbon buildup.

Mr. GAMMELGARD. I would venture to say that their gasoline contains other additives—the one that you say claims they have no additives in it. Gasolines may contain antirust, antiwear, antioxidant, antiicing additives, and others. But there are also differences in octanes. The average today is 100 research octane number throughout the United States for premium grade fuels. There are some around 98, 99. There are some that are over 100, so there as real quality differences. The point in this research project where we are looking, in one phase, at the "front end" or the first 10 percent of the boiling range is to what can be done to modify the hydrocarbon types in "front end" and the effect on evaporative losses from the fuel tank and carburetor. This could result in a general change in gasoline formulation but still have individual company differences. There are four different general types of hydrocarbons in gasoline—aromatics, naphthenes, olefins, and parafins, and we might find that a general change in a particular class would have an effect on automotive emissions as far as smog formation is concerned, and I think if this were found and demonstrated, that various companies would change their blends to make a positive contribution, but they would still have individual differences in their gasolines.

In 1968, in response to Federal emission standards, new automobiles will have exhaust control systems which will reduce to a very

considerable extent the hydrocarbon and carbon monoxide exhaust emission levels from automotive engines.

Some technical people are concerned that the exhaust control devices may result in accentuating the oxides of nitrogen problem while relieving the smog problem. While this is not a generally held opinion, it does suggest that our technology in this area may not be as far advanced as we would like it to be.

Mr. DADDARIO. Mr. Gammelgard, if the technology is not as far advanced as we would like it to be, are we moving ahead in the proper way? Should we, in fact, be imposing on the public the obligation to pay an extra $50 for this device? We must consider that as we multiply this by the number of cars to be sold, it will cost the public nearly one-half billion dollars a year. Since there is so much that we don't know, should we take a sum of money of that proportion and apply it to research in order to come up with a more meaningful solution?

Mr. GAMMELGARD. Mr. Chairman, I do not really have the feel of what oil industry thinks would be an answer to your question. I have my own opinion for what it is worth. I feel that this step of requiring these devices or controls—the law doesn't really require a device—it just says that what comes out the tailpipe may not exceed certain standards for carbon monoxide and for hydrocarbons—is a little premature. Currently, the 1966 Fords and Chevrolets being sold in California charge around $45 apiece for these exhaust control devices, plus around $5 for the positive crankcase ventilation device.

In my opinion $5 for the positive crankcase ventilation device which would reduce by about 30 percent the hydrocarbon losses is a very well worthwhile expenditure even though there are substantial geographical areas of this country where there is now no hydrocarbon air pollution problem. When it comes to paying $45 for an exhaust control device, I don't think there is any question that in California this was a very proper step to take in 1966. I think California has a problem of major proportions and even though you have technical people disagreeing as to whether these controls are going to be effective or not—or even might accentuate a different problem such as discoloration of the atmosphere by more nitrogen dioxide in the air—I think that California should have done what they did. Now, when it comes to a nationwide requirement for new cars, this might be considered, or I consider it possibly a little premature. It is a substantial sum of money when you are adding $45 to the price of a car. I should point out this figure is for Ford and GM. I understand Chrysler's device costs substantially less than that—I think it is in the $18 to $20 range. There is an economic advantage there. If the price of these devices can be brought down substantially and this is what Detroit's history has shown that they are capable of doing—bringing down costs of any item that goes in the car—it might be a little different.

Mr. DADDARIO. If you had available one-half billion dollars, would you spend it by buying these devices and adding them to new cars, or would you spend it in another way?

Mr. GAMMELGARD. Mr. Chairman, we couldn't come up with enough research projects to spend that type of money, good research projects. Dr. Eckardt, do you agree with that? You shake your head negatively, I don't know whether you agree.

Dr. ECKARDT. I don't think we could.

Mr. DADDARIO. There is a research problem. We are spending a half billion dollars to do something we are not certain about.

Mr. GAMMELGARD. We know the systems will reduce the unburned hydrocarbons. We know they will substantially reduce hydrocarbons and substantially reduce carbon monoxide. Carbon monoxide is becoming more and more of a problem in the city in heavy traffic. Not that it is a serious problem, but the carbon monoxide levels are going up at a rate where if they continue that way for another 10 years, they will become uncomfortable.

Mr. DADDARIO. I wouldn't want to impose on you or Dr. Eckardt to spend the half billion dollars. But could you spend a sum substantially less than that on research to accomplish more than we are now?

Dr. ECKARDT. I think so.

Mr. DADDARIO. In what way would you proceed, Doctor, if you were to take an alternative route?

Dr. ECKARDT. Well, there are some areas that I'm interested in in the medical field which I intend to discuss later in my statement and I think there are areas in the technical field where additional, perhaps novel methods of controlling exhaust might be worthwhile which would include also the control of the nitrogen-oxides.

Mr. DADDARIO. Why don't we wait until we come to your statement to explore further this question.

Chairman MILLER. Mr. Chairman, we talk about these devices we are going to put on automobiles. In California some years ago we had to use certain accepted devices on cars.

I realize that pollution is created by automobiles. I have no way of measuring it, but it seems to me that one truck or bus diesel engine creates as much or more pollution than 10 automobile engines do. I have driven across the continent perhaps as much as any man here; and many times I have pulled over to the side of the road rather than follow one of these trucks. What are we going to do about it? I live on the fifth floor of the Methodist Building, and during the height of the tourist season, there are 20 or more buses parked around the Supreme Court Building. During the summer, they run their motors to keep the air conditioning on while people go in and out of the building. Sometimes the pollution is so heavy in our apartment that we have to get out of it. What are we going to do about this kind of pollution?

Mr. GAMMELGARD. I think your order of 10 times is too high, Mr. Miller. The diesel engine is a very efficient engine and gets more power out of a gallon of fuel than an automobile and this is why it is used. I couldn't help but agree with you that the odors coming out of a diesel engine are obnoxious but I don't think the odors coming out of a diesel engine have any adverse health effect. In that respect, I think they have a cleaner bill of health than automobiles. But what you do get is this very disagreeable odor and in some cases smoke.

Now, things can be done to improve the smoking characteristics of diesels. The engines in general should be better maintained. This would help the problem. There are additives which will reduce the

smoke coming out of a diesel and these additives are being used more and more.

The engines too often are run underpowered by the operators which contributes to the smoke problems. If they would upsize the engines a little bit and operate them at the right point rather than "pushing" them this would help the problem. This sounds sort of wishy-washy, I guess. I recognize the problem but what are we doing about it?

There are some masking agents that some of the bus fleet operators are trying in their fuel to come up with a more desirable odor, and come up with something you don't mind as much as the normal odor. There is research being sponsored by PHS and other organizations on the diesel problems. It is going to be very difficult, I think, to completely get rid of this odor problem on diesels unless there is some technological breakthrough. This is the principal point against them, I think—just the odor—but I don't think there is any health problem with the diesel exhaust whatever—there is no control needed from that viewpoint.

Chairman MILLER. Thank you.

Mr. VIVIAN. I have listened to questions on this and asked similar questions some days ago and I am still left with the question of why is it so bad? What is the cause of the problem?

Mr. GAMMELGARD. I would presume that the primary reason for the problem is the formation of aldehydes in the exhaust—in the combustion products that come out of the exhaust pipe. Do you agree with that, Dr. Eckardt?

Dr. ECKARDT. Yes.

Mr. VIVIAN. These aldehydes are not formed in spark-ignited engines, is that right?

Mr. GAMMELGARD. Not to the same extent.

Mr. VIVIAN. Do they have any detrimental effect?

Dr. ECKARDT. About 40 years ago, a study on diesel engines was undertaken by the Bureau of Mines because they wanted to use them in mines where the ventilation was somewhat confined. Their study at that time indicated that the amount of exhaust coming out of a diesel, although obnoxious from an odor standpoint was not bad from a health standpoint and they permitted these diesels to be used.

Mr. VIVIAN. Is API currently carrying on any research in this field?

Mr. GAMMELGARD. Not in the health field. I indicated they are in the technical area.

Mr. VIVIAN. One of the purposes of the environmental pollution research is not only to make the atmosphere more capable for living but also more healthful.

Chairman MILLER. I would like to see local authorities enforce the law prohibiting the continued use of old cars which emit incredible amounts of exhaust smoke and fumes.

Mr. GAMMELGARD. I would like to discuss the question of industry-Government participation in abatement research and development. We certainly concur with the suggestion contained in your subcommittee's report that industry assume increasing responsibility for conducting much of the needed research, for this suggestion reflects your confidence in industry's capabilities and enlightened self-interest. We

also concur with Representative Robert S. Jones' testimony of July 20 before your subcommittee in which he recommended more participation by industry in research and development programs in the water pollution field.

I think we have already touched on what we cover in this next paragraph regarding Senate Report S. 3112.

Another viewpoint was expressed in a recommendation of the Senate Subcommittee on Air and Water Pollution report of July 7 (Rept. No. 1361) which questioned industry sponsorship of projects conducted by Federal agencies where "private economic interest as versus the general welfare are involved."

The oil industry, in many of its research projects, has worked closely with Government agencies, and two of our 1966 projects are being carried on jointly with the Public Health Service. Moreover, we look forward to more liaison and greater cooperation in jointly sponsored Government-industry research projects in the years to come. Currently, we are discussing the implementation of further projects with PHS.

For our project on the effects of various gasolines on automotive emissions, we were fortunate to enlist the cooperation of the Bureau of Mines. I say this because of the excellence of the Bureau's facilities, the competence of its personnel, and its absolutely unbiased position.

Industry would be criticized if it failed to sponsor work of the sort entailed in this project—and justly so. Government certainly could attempt such work independently. It is our view, however, that industry's intimate knowledge of its own product and processes can make a meaningful contribution to the success of such research. I would like to say here that there are several of the larger oil company research organizations capable of conducting this study. We chose the Bureau of Mines because we have full confidence in the Bureau—having worked with them over the years and whatever comes out of this research, we are ready to live with and I would hate to see any roadblocks thrown between Government and industry in this type of research.

It is our position that Government and industry must work together if adequate, effective, and reasonable pollution abatement methods are to be found, simply because no Government agency or group of agencies has, or can attain, expertise in all things.

One final point, gentlemen, regarding joint industry-Government research projects.

A question was raised in hearings by the Senate Public Works Subcommittee on Air and Water Pollution as to one detail of the contract I previously discussed, between API and the Bureau of Mines. As originally written, the contract included a standard clause prohibiting release of "technically valid and useful data"—in other words, preliminary findings—during the course of the study without prior approval of the other party. As provided in all API contracts, full disclosure is called for at the completion of the research. Full disclosure and free use by anvone of information developed in API research has always been API policy, and it continues to be.

On the basis, however, that the clause on preliminary disclosures might be interpreted as an attempt by a private interest to inhibit ac-

tion by a public agency, API stated publicly at the hearing that it would drop the clause. Since the hearing the contract has been amended so that it no longer calls for API approval of release by the Bureau of Mines of preliminary findings.

Mr. Chairman, I have read with great interest your opening remarks given at the start of these hearings. You stated that "sober consideration of the waste-products problem is a responsibility of all of us." I hope we are demonstrating here today that we in the petroleum industry have accepted our share of the responsibility.

As I have indicated, more research and technology on pollution abatement are certainly needed. At the same time, steps should be taken to insure that abatement action should be undertaken at no greater expense to the Nation than is necessary.

To meet this requirement, Mr. Chairman, we must certainly follow your recommendation that this issue should not be treated in an "atmosphere of crisis" and that solutions must be "solidly based on facts."

If decisions taken in the areas of quality criteria, legislation, and research and technology are calmly considered, based on sound data, and participated in by both industry and government, we are optimistic that our problems will be properly defined and that suitable solutions will be forthcoming.

Gentlemen, I want to thank you for this opportunity to outline our record and suggest some scientific and technological opportunities for the future. For the record, I'd like to file a copy of our very brief API policy statement on air and water conservation. Dr. Eckardt is now prepared to outline some of our medical and biological projects that we believe will interest you.

Mr. DADDARIO. Would you please proceed, Dr. Eckardt? Thank you.

Dr. ECKARDT. I appreciate the opportunity to appear here today and outline some of the work for you which the petroleum industry has been sponsoring in the area of medical research concerning air pollution.

STATEMENT OF R. E. ECKARDT, M.D., AMERICAN PETROLEUM INSTITUTE

Dr. ECKARDT. While the medical community is well aware of the acute damage which can be caused by high concentration of air pollution such as occurred in Donora, Pa., and in London, it is sorely lacking in data concerning the long-term, low-dosage effects of breathing the air in our environment. Our medical research has, therefore, been directed toward both of these areas.

Episodes are rare, as you know. But medical experts agree that in the few episodes that have occurred around the world, sulfur oxides, in combination with other pollutants, have beyond qeustion played a role. While awaiting a breakthrough on reduction of sulfur oxide emissions through either desulfurization of oil—and perhaps coal—or removal of sulfur oxides from stack gases, API feels that attention must be directed toward the prevention of future "episodes."

The engineering firm of Jackson and Moreland is now conducting an API-sponsored study in New York City to determine the feasibility, cost, and effectiveness of the plan we propose.

A similar study, also sponsored by API, and directed toward the prediction and prevention of episodes, and carried out by New York University, involves the evaluation of air monitoring methods and meteorological forecasting in the New York metropolitan area.

We would like to submit for the record a short paper on how such episodes might be controlled, written on behalf of the oil industry and delivered in June, at the Air Pollution Control Association meeting by Mr. Curtis G. Cortelyou of the Mobil Oil Corp.

Mr. DADDARIO. Without objection, that paper will be incorporated.

(The information requested is as follows:)

A PRACTICAL MEANS FOR COMMUNITY AIR POLLUTION CONTROL[1]

(By C. G. Cortelyou, Air and Water Conservation Coordinator, Mobil Oil Corporation, New York, New York)

In national magazines, in newspaper articles, and in several books that have come out in the past year or so, the promotion of the cause of pollution control has largely been based on the need to prevent air pollution incidents. The dramatic stories of the Meuse Valley, of London, of Donora have been told over and over because they emphatically point up pollution's hazards.

Beyond doubt such episodes, with their effect on human life, are the most clear-cut pollution problems. There is no question here. The need to end their threat is not under debate in any quarter that I know of.

Thus the episode is a problem upon which all of us can join in the attack—without reservations. Perhaps, we can reasonably question in medical, technical, and economic terms the need for complex and costly control of very low levels of specific pollutants. But no such question and no delay can be justified when it comes to the principal problem that we face—the air pollution incident.

It was in recognition of this that last year physicians and technical people working within the American Petroleum Institute developed what has come to be known as the API pollution incident control plan. It is, I believe, a constructive contribution to the science of air pollution control.

In studying the records of the health-damaging episodes most frequently cited, it is clearly seen that elevated levels of sulfur dioxides were present during each of them. But physicians in and outside the oil industry have told us that sulfur dioxide, although accused of being the villain of the piece, could not alone cause a health hazard at the levels recorded.

Sulfur dioxide, the physicians tell us, is largely filtered out in the mouth, nose, and throat when inhaled alone, and only a very small fraction gets into the lower respiratory tract. Thus, industrial workers have been exposed 5 days a week, 8 hours a day, year after year to sulfur dioxide levels of 5 parts per million—and even 10 and 20 parts per million—without bad effects. The industrial standard is 5 ppm, a level many times higher than that reached in any American community under the most adverse conditions.

In working up the API plan, a close examination was made of available data on known air pollution incidents that have occurred around the world. While high levels are safely encountered in industrial situations, it was found that sulfur dioxide levels during known pollution episodes were sometimes in a range of no more than 0.8 to 1 part per million.

Obviously, something special happens in the urban situation under adverse conditions—something not encountered in the industrial situation. The difference was clearly defined when top experts in the field from around the world gathered last year in New Hampsire at the Gordon conference on sulfur oxides and related compounds. Particulates, the experts generally agreed, play a crucial role in causing the air pollution incident. Sulfur dioxide is absorbed

[1] Presented at the annual meeting of the Air Pollution Control Association, San Francisco, Calif., June 23, 1966.

onto particulates, which are then breathed deeply into the respiratory tract. There the sulfur compounds can have a significant effect.

Our studies of specific episodes showed that in each case sulfur dioxide and particulates went up together, and remained up together for an extended period of time. The crucial point in devising the API plan, therefore, was to select some level of sulfur dioxide and some level of particulates which, together, would be safe. The development of a course of action to prevent those levels from being exceeded might then be attempted.

The first part of the effort was a close analysis of the past air pollution incidents in order to determine at what levels problems started. Our medical people determined that no health effects had ever been demonstrated when the two pollutants were together at or below the values that we since have built into our suggested control system. These values are 0.3 ppm of sulfur oxides and 4 "coefficient of haze" (Coh) units for particulates. If a way were found to determine in advance when these levels would be exceeded for an extended period, then it might be possible to tailor a community plan to reduce emissions of these pollutants at such times.

Industry technical people joined together to try to devise such a predictive system. They recommended that a network of air monitoring stations be established by any community where a pollution incident might develop. There recommendation called for the establishment of these units on a grid network of no more than five miles separation between units.

While sulfur dioxide is the predominant sulfur compound in ambient air, they recognized that there are other higher oxides of sulfur also present. These higher oxides, the doctors state, can have adverse effects on health as well, because they too, are adsorbed on particular matter and inhaled. So our technical people considered it preferable that the test method used in the monitoring proposal detect total sulfation. The American Society for Testing and Materials Designation: D–1355–60, Method A, was recommended as the appropriate procedure. It is a method that provides continuous measurement, through conductivity, of small concentrations of sulfur oxides. The standard method for determining soiling effects of smoke pollution—ASTM Designation: D–1704–61—was recommended as the procedure for determining ambient air particulate levels. In using this method, an air sample is pulled through a filter paper. The opacity of the deposit provides the measurement of the particulate matter.

Under the API control plan, whenever the average readings of the grid network show increasing levels of the two monitored pollutants, weather reports would be studied carefully. If the forecast indicates a period of stagnant air that might last 8 or more hours—either brought about by inversion or some other cause—then an alert would be called before the pollutant values built into the system are reached. The object would be to keep the levels of sulfur oxides and particulates below these values—0.3 ppm, SO_2 and 4 Coh.

Exactly what steps would be needed to accomplish this objective would have to be left for determination by the community itself according to the local situation. The community would need to study its various sources of emissions and design a series of steps to be required should an alert be sounded. Among possible steps for consideration are a reduction of incineration and the halting of open burning (if this hasn't already been completely prohibited by law). Other steps might include switching to lower sulfur content fuels temporarily in plants where burning of such alternate fuels could be made possible; and, perhaps, the modification of certain industrial operations for a time in order to produce a net reduction in pollutant emissions.

The maximum levels for SO_2 and particulates, in combination, that have been built into our system are stringent. The record of past pollution incidents does not show these levels to present health hazards. Yet action would be called for to cut emissions before such levels are reached. Thus a considerable safety factor has been built into the plan.

Even though the levels in the system are stringent, it is a fact that few cities ever reach these concentrations for extended periods. In a community where the combination of factors might be possible, it will usually occur at most no more than two or three times a year.

This is a positive system to predict and prevent pollution incidents. It can be established to supplement a program of reasonable year-round ambient air objectives. But objectives alone, calling for maximum levels of particular pollutants such-and-such percent of the time, cannot assure the avoidance of episodes. Whether year-round objectives are met can only be determined

after the fact. Our system, we believe, can predict episodes before they occur and make it possible to prevent them.

The American Petroleum Institute is sponsoring a study of the feasibility, cost and effectiveness of this pollution incident control plan. The study is now underway in the most densely populated and most complex air shed in the nation, the New York metropolitan area. It is being conducted by Jackson and Moreland, a reputable, independent consulting engineering firm of Boston, Massachusetts. For several months Jackson and Moreland engineers have been gathering data from a wide variety of sources within New York City and outside it. They have interviewed business executives, city officials, and other individuals who either have expertise in pollution control or are responsible for particular pollution sources. They have contacted control officials and meteorologists, as well as experts from the academic world. Particular attention is being given to checking the weather forecasting aspect of the plan.

Dr. Leonard Greenburg, former New York City Commissioner of Air Pollution Control, is serving as a consultant to the engineers on this project. As you know, he is now chairman of the Department of Preventive and Environmental Medicine at the Albert Einstein College of Medicine in New York.

By the fall, Jackson and Moreland is scheduled to give us its judgment. I will not anticipate what that judgment will be.

The plan under study could only be implemented at a cost—but we believe it will be a minimum cost to accomplish what must be accomplished, protection against the possibility of health-damaging air pollution incidents.

That end, of course, could be achieved by the complete elimination of all pollutant sources—but this is impractical. What we have put forward is a plan that we feel is achievable now and that meets the urgent need.

The pollution incident control plan is not the answer to all pollution problems. It does not take into account other factors beyond health protection; it does not prevent corrosion, plant damage or soiling of clothing. Judgments on steps to take to deal with these latter effects can be determined on an economic balance—weighing value to be achieved against cost of achieving it.

Our plan is one solely dedicated to the elimination of the air pollution incident which holds the potential of health damage. We do not say: forget about the other effects of air pollution. We do say: let's get on with the job of eliminating this one very clear threat of health damage, and do so without delay.

In some cities year-round reduction of the total pollution load must be achieved. But no one has yet found a way to accomplish this overnight.

No delay, though, should be tolerated when it comes to dealing with the air pollution incident. Some way must be found, as we make our steady progress toward the reduction of total pollution, to assure that under adverse circumstances pollution incidents will never again occur in this country.

If our plan or some refinement of it is not the answer to the problem of the air pollution incident, one should certainly be found. And I believe you would agree that such a plan should be put into effect as promptly as possible. A long-term schedule for achievement of *this* goal is *not* reasonable.

We are proposing, then, what we hope will be a practical answer to the air pollution incident.

The feasibility study on the plan is just one of many efforts being conducted within the petroleum industry in the air conservation area this year.

Underway within the API are air pollution research projects costing well over $1½ million in 1966 alone. Within individual companies of the industry another $41 million is being dedicated this year to air conservation capital expenditures and research. An additional $210 million has been spent in those areas by oil companies in the last ten years.

Knowing all that can be learned about sulfur oxide pollution and any other pollution problem that might be associated with the industry's operations or products is of very great concern to us. We are sincerely dedicated to air conservation, and we will continue to seek in every way possible to work with others from within industry, from within government, and from among the general public who are joined in the same cause.

Dr. ECKARDT. Very few large epidemiological studies have been undertaken because of their high costs and because they contain so many variables including substandard food, housing, and clothing.

I have attempted to summarize some of these studies in a paper that was published in the Journal of Occupational Medicine in 1964 and I would like with your permission to enter a copy of this study into the record.

(The paper follows:)

[From the Journal of Occupational Medicine, April 1964]

Air Pollution, Lung Cancer, and Chronic Lung Disease

(By Robert E. Eckardt, M.D., Ph. D., Linden, N.J.)

Dr. Eckardt is Director, Medical Research Division, Esso Research & Engineering Company, Linden, N.J.

In recent months an increasing amount of publicity has been given to the health effects of air pollution, so much so that Dr. F. Princi was moved to refer to this as "overwhelming, persuasive and deceptive propaganda," in his Chairman's address to the Section on Preventive Medicine of the American Medical Association (1). Most of this publicity revolves around two conditions—namely, lung cancer and chronic pulmonary disease (chronic bronchitis, pulmonary fibrosis, and emphysema). Unfortunately, those who are convinced of the causal relations between air pollution and health effects are prone to ignore those reports that do not support their concepts. The purpose of this brief review is to point out a few reports which are often overlooked, yet which raise serious questions about the state of our knowledge. It is to be recognized that this review emphasizes those reports which throw some doubt on the causal relationships of air pollution and health effects. It should not be assumed, however, that I do not support air pollution control measures or the desirability of reducing general air pollution, or even that I take the view that there is no causal relationship between air pollution and health effects. Essentially the author believes that there is a strong suggestion of such causal relationships, but that much more reseach is necessary to establish them. In the meantime, I believe reasonable and practical air pollution control measures should be applied wherever possible, if only to control the filth, plant damage, nuisance, and annoyance that air pollution can bring. This report will be divided into two parts—one dealing with lung cancer and the other, with chronic pulmonary disease.

LUNG CANCER

In 1961 a most interesting paper appeared by Gilliam *et al.* (2) of the Field Investigations and Demonstrations Branch of the National Cancer Institute, U.S. Public Health Service. In this paper, mortality rates from lung cancer were carefully analyzed over the period 1930 to 1956. They found that during this period there had been a steady and quite regular decrease in the rate of increase (prevalence) of lung cancer. In their discussion, with the basic assumption that these trends continue, they state:

"The general regularity since 1930 of the declining percentage increase in rates for all ages, particularly among the white population, suggests that the most appropriate method of projection might be to fit a straight line to these percentages of change. When this is done, the rate of increase approaches 0% for the white female population in 1960 and for the male population in 1983. That is to say, then, that if present trends follow this pattern, recorded lung cancer mortality must reach a peak about 1960 for the white female population and about 1983 among the white male population and then decline thereafter."

Even though later, when analyzing the age-specific declines of rates of increase, they conclude that, "The peak would be delayed until about 90 years later and would be about 20 times as high as that predicted by projection of all ages rate of change," nevertheless they add: "No matter what method of projection is employed, a peak with subsequent decline *must* follow a declining rate of increase." (Emphasis theirs.)

The importance of this concept to present thinking lies in the fact that many who believe there is a causal relationship between air pollution and lung cancer have stated that, if air pollution is reduced and the rate of increase of lung cancer declines, this is proof of the causal relationship between the two. Gilliam

and co-workers predict that the rate will go down even if we do not reduce air pollution, so that a simple decrease in rate is no proof of causal relationships. Another possible interpretation of this data is that if air pollution and lung cancer have a causal relationship, whatever it is in the air that was responsible for this has already begun to decrease. One could speculate that substitution of oil for coal, beginning about 1930 in significant amounts, has already begun to remove the lung carcinogens from the air.

In 1958, C. O. S. B. Brooke of the Finsbury Health Center, London, examined carefully the statistics on lung cancer deaths for England and Wales for the 1932–1956 period (3). He interpreted the data as suggesting that cancer of the lung seen now may have been at least partly determined during the patient's teens. Further, an almost explosive increase in bronchocarcinogenic factors appears to have occurred early in the century, although some regression may have occurred since 1915. In brief, his data support generally, if not in every detail, the data of Gilliam *et al.* quoted above. Beebe (4), in 1960, analyzed lung cancer deaths among World War I veterans, and concluded that lung cancer was slightly increased in those who had been subjected to mustard gas poisoning in 1918, although no such increase was observed in those who had pneumonia or wounds of the extremities.

Barnes and Ratzenhofer (5) reviewed 26,546 autopsies at the University of Graz, Austria, finding 868 cases of lung cancer. Apparently lung cancer is far more prevalent than other malignancies as a cause of death in persons having tuberculosis. Since the advent of modern chemotherapy for tuberculosis, more people survive tuberculosis than previously, living on to develop lung cancer at a later date. Confirming this, Herdan (6), of the University of Bristol, pointed out that certain apparently unrelated occupational groups showed a significantly high or low standardized mortality ratio for respiratory tuberculosis in 1930, and these same groups now have a significantly high or low ratio for lung cancer, with their tuberculosis mortality greatly reduced. It was suggested that sulfa drugs and antibiotics have reduced mortality due to epidemic and inflammatory lung disease, thus making way for the action of a disease of genetic origin. This would affect males more than females because males are more subject to recessive genes that transmit lethal conditions.

In another statistical paper, Manos and Fisher of the U.S. Public Health Service found (7) high positive correlations of various indices of air pollution that they developed with the following diseases: cancer of the esophagus, stomach, trachea, bronchus, and lung; arteriosclerotic heart disease, including coronary disease; and chronic endocarditis not specified as rheumatic and other myocardial degeneration. Although there may be some good reason for such correlations in some of these conditions, it is difficult to postulate the rationale for others, such as chronic endocarditis. This suggests the possibility of some third factor common to all the diseases and also to an air pollution index.

Kreyberg (8), of the University of Oslo, found that the air in one gas works contained amounts of benzpyrene corresponding to some 5,000 cigarettes daily for the 40-hour week, but only a moderate excess, if any, of lung cancer in the gas workers. It is possible that there may be no relationship at all between lung cancer and benzpyrene. This possibility was also suggested by Hueper *et al.* (9), who could find no correlation between reported lung cancer mortality and the amount of 3:4-benzpyrene or the carcinogenic potency (determined by injection under the skin of mice) of particulates found in the air of eight specially selected U.S. metropolitan areas. There has been a tendency on the part of many air pollution investigators to use benzpyrene content of the air as a measure of pollution, and hence of the hazard of lung cancer. These data suggest that this cannot be done.

Wynder (10), of the Sloan-Kettering Institute for Cancer Research, found that the lung cancer incidence in Venice, presumably with a very low air pollution level, at least from auto exhausts (because of its canals), was no different from other Italian cities. This suggests that the elimination of auto exhaust might not influence lung cancer rates.

Perhaps one very distressing situation in regard to lung cancer is the lack of reliable statistical data on the incidence of lung cancer in various cities. Thus Manos (11), of the U.S. Public Health Service, published a large volume providing mortality indices for various causes of death, including lung cancer, in a series of cities in the United States. These indices presumably provide a measure of the amount by which a given cancer rate in a given city exceeds or

is less than the average for the country as a whole. Thus an index of 0.80 indicates an incidence 80% of the United States average, and an index of 1.20 indicates an incidence of 120% of the average. In studying Manos' data a series of cities with an index higher than normal, or representing a spread from less than normal to higher than normal, can be selected. Presumably, then, these can be related to some "index" of air pollution, be it by benzpyrene, ozone, hydrocarbons, or whatnot. However, indices reported by Gilliam (12) for many of the same cities do not coincide; thus, cities with high indices for lung cancer on Manos' list, may have normal or low indices on Gilliam's list. This then presents to the investigator the quandary as to which index to use in any air pollution correlation studies. In an attempt to resolve this, I corresponded with both Manos and Gilliam. The result was further confusion, when Gilliam (13) indicated that probably neither index was correct. This then throws considerable doubt on any conclusions drawn concerning the correlation between air pollution and lung cancer or any other disease.

Finally, although this review is confined almost entirely to data for human beings, one piece of animal data is worthy of mention. Mari-Chanez (14), a director of the Cancer Research Laboratories in Peru, compared the incidence of pulmonary tumors in Strain A mice kept at 14,900 ft. with those kept at sea level. The incidence in the former was 61.4% and in the latter, 53.0%, which the author did not believe statistically significant for the numbers of animals used (386). However, the animals kept at high altitudes developed more tumors greater than 4 mm. in size than those kept at sea level. It should be remembered that Strain A mice are being widely used to test the "tumorigenicity" or "carcinogenicity" of air pollutants. If such nonspecific effects as altitude can affect the incidence or size of such tumors, then it is not surprising that very high levels of "air pollutants," such as are used by experimentalists, might have a similar nonspecific effect.

CHRONIC LUNG DISEASE

Gocke and Duffy (15), of the Seton Hall Medical School, found a striking correlation between smoking and chronic bronchitis. Just as in lung cancer, the association between chronic lung disease and smoking seems far stronger than any association between chronic lung disease and air pollution. These observations have been confirmed by Schoettlin (16) in Los Angeles. In a study of 3000 elderly males, he found a higher prevalence of chronic respiratory disease in certain selected occupations and in those who had smoked more than 10 years. When matched for age and smoking, no significant correlations could be made between measures of weather, air pollution, and pollen, and observations of symptoms, physical signs, or pulmonary function in men with chronic respiratory disease and in controls. Again, this suggests that smoking is a far more important factor than air pollution.

Brinkman and Coates (17) studied the influence on bronchitis of increasing age, dust exposure, and cigarette smoking in 1317 men, aged 40–65. They found that smoking appeared to be the most aggravating factor.

Another study which has received much attention is that of Prindle *et al.* (18). In this, the pulmonary function of residents of two cities in Pennsylvania, Seward and New Florence, was studied. The cities, separated by a few miles, had a large power plant between them. The prevailing wind was such that one town was polluted with the effluent of the power plant, while the other was not. It was found that statistically significant differences in average height between the residents of the two cities were of a sufficient magnitude that average airway resistance could be affected. Since airway resistance was one of the measures of pulmonary function that showed differences between the two towns, it is not certain whether these differences were due to the air pollution or to this height difference. At present, height differences are not receiving the emphasis that they should, although the airway resistance differences are being suggested as resulting from the air pollution.

In a later report of this data by Prindle *et al.* (19), the authors state:

"After adjustments are made for age and height in comparing the two communities, results for both sexes in New Florence in relation to both in Seward reveal a surprising similarity. This is evident for each pulmonary function measurement except for Average Airway Resistance and Airway Resistance × Volume. These were higher for Seward than for New Florence. The dif-

ferences for each sex between the two communities for these two measurements could not be explained by differences in age or height. The differences may be due to difference in air pollution levels or to other variables which have not been examined thus far. * * * other variables in addition to age, sex, and height, which are assumed to have an effect on pulmonary function test results include weight, body surface area, smoking habits, occupation, and length of residence in the community. Each of these variables is being evaluated."

Thus, it appears far too premature to single out air pollution as even the possible cause of the difference in these two pulmonary function measurements between the two towns. For instance, a review of smoking habits reveals 21% nonsmokers in New Florence males, but only 18% in Seward males. For females, the comparable figures were 75% and 63%. Most observers believe there is little doubt about the effect of smoking on pulmonary function, so it would seem that these differences in smoking habits would more likely be responsible for the differences in pulmonary function than differences in air pollution.

In the X-ray study, the proportion of pneumoconiosis (dust disease of the lung, including silicosis) in Seward males was more than twice that for New Florence. It is speculated that this may result from the greater proportion of coal miners in Seward. Of the New Florence male group, 37.1% were "normal" on X-ray examination, whereas 36.4% of the Seward male X-ray examinations were so interpreted. However, the New Florence group shows a larger percentage of males with emphysema. On the other hand, 6 of 10 X-ray examinations of females in Seward were reported "normal," whereas only 5 of 10 of those of females in New Florence were so reported.

Dohan *et al.* (20) studied absences of 8 days or more from respiratory disease among female employees of the same company located in several cities. These absence rates were then correlated with various measures of air pollution. A correlation was found to exist between particulate sulfates in the air and this absence rate. However, for this study to have real meaning, respiratory illnesses causing absences of less than 8 days should also be studied, and absences from respiratory diseases among male employees of all durations should be studied. Additionally, looking at Dohan's data, a positive correlation can also be found between the absence rates studied and atmospheric vanadium and nickel, and a reverse correlation can be found with zinc.

Two conditions, possibly related but quite possibly distinct entities, are "Yokohama" asthma and "New Orleans" asthma. The first of these is found in U.S. servicemen stationed in the Tokyo-Yokohama region of Japan. It appears that the only sure cure is return of the patient to the United States. Just what percentage of servicemen is involved is not certain, but it seems to be considerably less than 100%, perhaps as high as 10%. Phelps and Koike (21) found that it is more likely to occur in individuals who had a past history of bronchitis or who were heavy cigarette smokers. The second condition, "New Orleans" asthma, was studied by Lewis *et al.* (22) Their studies were confined to Negroes since Negroes constituted the major patient load at the hospital where their studies were done. They found that the condition seemed to be associated with incomplete combustion particles containing silica. They believed these particles to arise from abandoned city dumps which periodically burst into flames. Certainly this could not be considered either an "industrial" pollutant or an automotive exhaust pollutant, yet there is a tendency for writers to relate the condition to ordinary general atmospheric pollutants. About the most that can be said at this time is that the exact causes of "Yokohama" or "New Orleans" asthma have not been completely worked out. Although perhaps related to air pollution, this is a relatively circumscribed air pollution which does not affect the total population, but only those persons peculiarly susceptible to it. For instance, it is not known whether Japanese residents of Yokohama are affected in the same way as United States service troops stationed there, or whether white residents of New Orleans are affected similarly to the Negro.

Zeidberg and Prindle (23) in summarizing their studies in Nashville state:

"Pulmonary anthracosis appears to reflect an individual's exposure to environmental air polluted with coal dust.

"No association was found between anthracosis and specific pulmonary or cardiac symptoms or pathology."

Although no mention is made by the authors of sulfur dioxide, it must be presumed that, in a predominantly coal-burning town such as Nashville, the atmospheric sulfur dioxide levels would increase at least directionally as the

environmental pollution with coal dust increased. Thus, this study presents presumptive data also that exposure to sulfur dioxide, at least at the levels found in air pollution, is not associated with specific pulmonary or cardiac symptoms or pathology.

In previous studies in Nashville, Zeidberg *et al.* (24) found that the average asthma attack rates on the 30 days with the highest SO_2 levels were significantly higher at the 5% level than the average attack rate on the 46 days with the lowest SO_2 levels. If the daily data on asthmatic attacks were deferred one day to take account of possible delayed SO_2 effects, the differences in rates were significant at the 1% level. However, even the authors acknowledged that asthma is not a very good disease to study in relation to single causes because "many factors have been listed as the cause of bronchial asthma," including allergens, meteorologic and aerometric factors, emotional factors, and infections. Any clinician treating asthmatics knows that trades involving the breathing of nonspecific dusts must be avoided by their patients. These Nashville studies found inverse relationships between attack rates and wind velocities, thus suggesting that still, quiet days with high probability of inversion prevailed when SO_2 was elevated. On such days, all pollutants including soiling, particulates, pollens, etc., as well as SO_2, would be increased.

CONCLUSION

As indicated in the opening paragraphs of this review, it is not the intent to imply that correlations between health effects and air pollution might not exist, but only to bring an awareness of frequently overlooked reports which suggest that the state of our knowledge at this moment is far from complete. Suggestions have been made which warrant further intensive investigation, but it is far to soon to draw any positive conclusions. It is to be hoped that those who are putting forth the "overwhelming, persuasive, and deceptive propaganda" will give pause to their efforts and take cognizance of these reports before they precipitate costly undertakings which may not be effective.

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Dr. ECKARDT. To remedy to some extent the lack of information about long-term effects of air pollutants on our population, the API is now preparing to participate in a continuing epidemiological and clinical survey now being conducted in Chicago. The purpose of this study is to document the possible chronic and/or acute health effects of sulfur oxides and particulates by correlating clinical data from health agencies with changing levels of these pollutants. This program, which will require an acceptable air monitoring system, will hopefully be carried out in conjunction with the Air Quality Standards Committee which serves the Department of Air Pollution Control of the City of Chicago.

Another related project involves the exposure of laboratory animals to controlled atmospheres. This project, too, is designed to determine the possible effects of chronic long-term, low-dosage exposure to polluted atmospheres. The materials to be studied include sulfur dioxide and nitrogen oxides, plus particulates, in various combinations. This particular project is being carried out by the Industrial Hygiene Foundation, while another project quite similar is being sponsored by the API at the University of North Carolina.

A number of research projects in which the petroleum industry is participating involve the study of lead in the environment.

One project will conduct medical studies that may detect the subclinical effects on lead in man, or the effects of lead, if any, on well-established clinical conditions—such as heart or kidney diseases.

For a severe test of lead effects, we are also sponsoring a project that will feed laboratory animals amounts of lead far above levels normally encountered, for a long period of time. This study will be conducted by Hazleton Laboratories.

Another study at the Kettering Laboratory of the University of Cincinnati will be conducted to determine the lowest level of lead in the atmosphere that will produce a measurable change of lead in the blood.

Still another project, conducted for API and the Lead Industries Association by Wayne State University, is studying the lead burdens of laboratory animals exposed to heavy concentrations of automotive emissions with the lead burdens of other animals that have not been exposed to such concentrations. This study is a continuation of a major study begun by the Public Health Service.

Although questions have been raised concerning the possible health hazards of lead, the API, on the basis of available medical data, does not believe that a hazard now exists or will exist in the immediate future. However, we are ready to carry forward the mandate of continued surveillance that is implied in the report of the Environmental Pollution Panel, the proceedings of the symposium on lead of December 1965, and the report on the tricity study itself. API would welcome the joint sponsorship by the Public Health Service of such a project.

This concludes my statement and, gentlemen, I thank you for the opportunity of appearing here today.

Mr. DADDARIO. I am somewhat confused, Doctor, about the meaning of your last paragraph. Are you conducting this research on the possible effects of lead under some kind of a compulsion which is not based on any real need?

Dr. ECKARDT. No; the prediction has been made that if the automobile population doubles by 1980 and if lead continues to be used in the gasoline during this period, then although there is not a hazard now, ultimately a hazard might develop. We feel that we should continuously monitor the atmosphere for its lead concentration and the people, a representative sample of the population, in order to make sure that there has been no increase in either the lead in the atmosphere or the lead in the people. I think our industry is perfectly prepared to take lead out of the gasoline or at least reduce its content if there is any evidence that this is occurring or this has been increasing. The thing that has interested us in this area is that in the city of Cincinnati which is one of the few cities that have good data because Dr. Kehoe has been doing work there since 1920, even though the automobile population tripled, the average concentration of lead in the atmosphere in that area has been going down, so we do not feel that necessarily there is a relationship between the automobile population using lead and the lead in the atmosphere that people may be breathing. Therefore, we feel that this type of survey should continue to make sure that nothing is going to happen in the future.

Mr. DADDARIO. Wouldn't you emphasize the studies of the effect of lead in animals and in humans on the premise that a cumulative dosage over a long period of time could be harmful?

Dr. ECKARDT. Well, this is certainly true. Let me say there is no question about the toxicity of lead. The question is the hazard and the hazard is related to the level of lead that people are exposed to. In other words, if you take too much lead there is no question that it is toxic. Our position in the API is that people are not taking in too much lead and they are not being subjected to a hazard. Does this answer your question, sir?

Mr. DADDARIO. Partially, but I am still concerned about the overall problem. Because we have no way of measuring the potential harm.

We don't seem to be conducting the necessary research to determine the long-range effect of lead pollution. We could find ourselves in a position where the health of the Nation was in fact periled only because we hadn't conducted the necessary research early enough to obtain an early warning.

Dr. ECKARDT. I think the best measure of lead is the determination of lead in the blood and urine of humans. This is just what we in industry do to follow our lead workers and make sure they are not subjected to a health hazard and which we know from following these men that if their lead intake does not exceed a certain level, they do not accumulate it. There is a balance established between the intake and excretion of lead and it is only when you raise this level and change this balance that you may run into difficulties.

Now, the levels of lead that the general population is exposed to in comparison with industrial workers is perhaps of the order of 20 times less than industrial workers. And, of course, having studied these industrial workers over many years we feel they have not accumulated lead if they are not permitted to be exposed to a level in excess of a figure that has been set by the American Conference of Governmental Industrial Hygienes. This is a stated working level for workmen and I don't know whether I have still answered your question.

Mr. DADDARIO. You could argue, however, that that level that has been established is not in fact a proper level or that the research has not been adequate. Simply because people aren't keeling over and dropping deal does not mean that it may not be harmful.

Dr. ECKARDT. These men have been examined since the 1920's with no measurable effect on their health that we can see.

Mr. DADDARIO. We know that the human body is absorbing and accumulating certain amounts of certain substances such as lead and insecticides. The point has not yet been reached where a proper determination can be made to gage the effect on a human being over a long period of time of an accumulation of these types of substances.

Dr. ECKARDT. You mean in combination?

Mr. DADDARIO. Yes.

Dr. ECKARDT. This, I would agree but lead alone I think has been studied perhaps more than any metal we know. We know more about lead than perhaps any other metal that we know anything about.

Mr. DADDARIO. Despite the fact that you don't believe any such cumulative effect now exists or will exist, do you agree that research should be conducted so that we do, in fact, come to a determination as to whether or not such an effect is possible?

Dr. ECKARDT. Absolutely.

Mr. VIVIAN. I was curious about your statement indicating that the amount of lead in the air in Cincinnati has not increased or decreased over a period of 30 years. Is that because less lead is used per gallon?

Dr. ECKARDT. No, this is because coal burning in the Cincinnati area has decreased, and you have to remember that coal probably contributes about as much lead in the atmosphere as the lead from the automobiles.

Mr. VIVIAN. Is this residual lead in the coal as opposed to added lead in the automobiles.

Dr. ECKARDT. This is just natural lead. This is not added to coal. And it is Dr. Kehoe's belief, now I don't know whether he has absolute proof, that it has been the reduction in coal burning in the Cincinnati area that has reduced the lead concentration in that city and even though the automobile population has tripled in that city, the air concentration is going down.

Mr. GAMMELGARD. I would like to make one point, Mr. Chairman. We have a research problem to determine for the industry the incremental cost of making today's quality gasoline without lead. At the Public Health Service sponsored symposium on lead in December last year, two companies outside of the petroleum industry gave data. One indicated 1.1 cent per gallon, and the other gave 2.9 cents as the additional cost of making unleaded gasoline. We made the statement that we would develop our own study for the industry which certainly seems reasonable and logical. (This study is underway.)

I would like to point out that there are some 70 billion gallons of automotive gasoline sold in the United States in a year. A 1 cent per gallon increase is $700 million added annual cost to the motoring public. Two cents is $1,400 million, and the 3 cent figure which one of the companies gave would be over $2 billion. These are costs that we do not want to pass on to the public unless there is good solid reason for doing it. And I also would like to make this statement. I drive a great deal, I drive on tollways, freeways, and in city traffic where the concentration of cars is heaviest. I am not personally the least bit concerned about the level of lead in the atmosphere today. If in our opinion the health of the people is truly involved—as Dr. Eckardt said there is no question what we would do, but we don't think we should go ahead and make this move without a thoroughly good case for it because it would cost the public huge sums of money.

Thank you, sir, for the time.

Mr. DADDARIO. Gentlemen, because we have two further witnesses, I would like to send you further questions for the record. (Additional questions and answers for the record may be found in vol. II.)

Mr. GAMMELGARD. Thank you.

(The complete prepared statement of Dr. Robert E. Eckardt follows:)

PREPARED STATEMENT OF ROBERT E. ECKARDT, M.D.

I am Dr. Robert E. Eckardt, medical adviser of the Committee for Air and Water Conservation of the American Petroleum Institute. I appreciate the opportunity to appear here today to outline for you some of the work which the petroleum industry has been sponsoring in the area of medical research concerning air pollution.

By its very nature, air is a complex substance, and since we have until recently been attuned to the habit of taking for granted the air we breathe, we have devoted little attention to investigating this resource and its effect upon the health of humans.

Together with others in industry and in government, we are now attempting to rectify this lack of knowledge, and a portion of the API's $2 million research budget is devoted to medical research. Some of the projects are being conducted in universities, government agencies, and in private research institutions.

As with any medical research of value, various safeguards and controls have been established that explain our reluctance to accept quick answers and snap judgments. But certainly our increasing knowledge of health effects will influence the future course of technology for pollution abatement, and hopefully might influence the establishment of priorities. To indicate how this might be

so, I would like to briefly describe some of our projects in this area, and discuss some medical research opportunities for the future.

While the medical community—and the API—is well aware of the physical damage which can be caused by high concentrations of air pollutants, such as have occurred in Donora, Pennslyvania, and in London, it is sorely lacking in data concerning the long-term, low-dosage effects of breathing the air in our environment. Our medical research has therefore been directed toward both of these areas.

Episodes are rare, as you know. But medical experts agree that in the few episodes that have occurred around the world, sulfur oxides, in combination with other pollutants, have beyond question played a role. While awaiting a breakthrough on reduction of sulfur oxide emissions through either desulfurization of oil or removal of sulfur oxides from stack gases, API feels that attention must be directed toward the prevention of future "episodes."

Sulfur dioxide, when inhaled as a single pollutant in ambient air, is largely filtered out of the respiratory tract in the mouth, nose and throat. But under episode conditions, with high levels of many pollutants in the air, significant amounts of sulfur oxides can get down into the lungs. This happens because sulfur oxides are absorbed onto particulate matter which has also undergone a buildup. When breathed deeply, extremely small particulates with adsorbed sulfur compounds are carried into the respiratory tract. In unusual concentration, this combination can have a significant effect.

API has made a study of past episodes and determined that if certain levels of these two pollutants, in combination, can be avodied, an episode probably would never occur. We would like to submit for the record a short paper on how this might be accomplished, written on behalf of the oil industry and read in June before the Air Pollution Control Association by Curtis G. Cortelyou of Mobil Oil Corporation.

The engineering firm of Jackson and Moreland is now conducting an API-sponsored study in New York City to determine the feasibility, cost, and effectiveness of the plan we propose.

A similar study, also sponsored by API, and directed toward the prediction and prevention of episodes, and carried out by New York University, involves the evaluation of air monitoring methods and meteorological forecasting in the New York metropolitan area.

I mentioned medical research inadequacies about the effects of long-term, low-dosage effects of breathing the air in our environment. Very few such large-scale epidemiological studies have been undertaken because of their high cost and incorporation of so many variables, including sub-standard food, housing, and clothing. I have attempted to summarize the history of such studies in a paper published in the Journal of Occupational Medicine in 1964 and I would, with your permission, like to enter a copy of this paper in the record.

To remedy to some extent the lack of information about long-term effects of air pollutants on our population, the API is now preparing to participate in a continuing epidemiological and clinical survey now being conducted in Chicago. The purpose of this study is to document the possible chronic and/or acute health effects of sulfur oxides and particulates by correlating clinical data from health agencies with changing levels of these pollutants. This program, which will require an acceptable air monitoring system, will hopefully be carried out in conjunction with the Air Quality Standards Committee which serves the Department of Air Pollution Control of the City of Chicago.

Another related project involves the exposure of laboratory animals to controlled atmospheres. This project, too, is designed to determine the possible effects of chronic long-term, low-dosage exposure to polluted atmospheres. The materials to be studied include sulfur dioxide and nitrogen oxides, and particulates, in various combinations. This particular project is being carried out by the Industrial Hygiene Foundation, while another project quite similar to this is being sponsored by the API at the University of North Carolina.

A number of research projects in which the petroleum industry is participating involve the study of lead in the environment.

One project will conduct medical studies that may detect the sub-clinical effects of lead in man, or the effects of lead, if any, on well-established clinical conditions—such as respiratory diseases.

For a severe test of lead effects, we are also sponsoring a project that will feed laboratory animals amounts of lead far above levels normally encountered, for a long period of time. This study is budgeted at $250,000 and will be conducted by Hazleton Laboratories.

Another study is being carried on in cooperation with the Public Health Service, du Pont, Ethyl Corporation, and the Lead Industries Association, at the Kettering Laboratory of the University of Cincinnati. It is attempting to determine the lowest level of lead in the atmosphere that will produce a measurable change of lead in the blood.

Still another project, conducted for API and the Lead Industries Association by Wayne State University, is studying the lead burdens of laboratory animals exposed to heavy concentrations of automotive emissions with the lead burdens of other animals that have not been exposed to such concentrations. This study is a continuation of a major study begun by the Public Health Service.

Regarding future medical research on pollutants of particular interest to the oil industry, API proposes the following conclusions for the consideration of this Committee and the Congress.

Although questions have been raised concerning the possible health hazards of lead, the API, on the basis of available medical data, does not believe that a hazard now exists or will exist in the immediate future. However, we are ready to carry forward the mandate of continued surveillance that is implied in the report of the Environmental Pollution Panel, the proceedings of the Symposium on Lead of December 1965, and the report on the Tri-City study itself. API would welcome the sponsorship by the Public Health Service of a project that would provide early detection if any tendency toward lead accumulation should occur in the population. We would be indeed pleased to cooperate with the Public Health Service in such a study.

This concludes my statement. Gentlemen, may I thank you again for the opportunity to appear here today.

Mr. DADDARIO. Our next witness is Dr. Arthur M. Bueche, vice president of the research and development center, General Electric.

STATEMENT OF DR. ARTHUR M. BUECHE, VICE PRESIDENT, RESEARCH AND DEVELOPMENT CENTER, GENERAL ELECTRIC CO.

Dr. BUECHE. Mr. Chairman, with your permission, I would like to have Mr. R. Ned Landon come and sit beside me.

Mr. Chairman, the task which your committee has set for itself ranks in importance with the most pressing challenges of modern society. I believe I speak for industrial research people generally in saluting you—and thanking you—for your outstanding efforts on behalf of improving the quality of life in our Nation.

As I will discuss later, it seems to me that the job of cleaning air and purifying water will be completed most rapidly if attacked on a competitive basis, seeking the most economic solutions and offering a profit incentive to those who learn how to do the job best.

At the same time, it would be folly to suggest that private enterprise alone can solve this massive national problem. There is an urgent need for cooperative action by government—at local, State, and National levels—to establish the permissible limits of pollutants and set the necessary goals and schedules for attaining a healthy—and aesthetically satisfying—environment.

Unfortunately, no one is now in a position to establish permissible pollution limitations, or long-range goals and schedules, because the problem is not sufficiently understood.

Congress cannot effectively outlaw cancer, because no one yet knows what causes it. In somewhat the same way, you have this problem with pollution. We know a good deal, but not enough, about what pollutants are in the air, water, and ground. We know a good deal, but not enough, about how they got there. We know very little, and nowhere near enough, about the actual effects of these so-

called pollutants on either inanimate materials or living plants and bodies.

Research—lots of research—is urgently needed. In what areas of science? Who is going to do it? Who is going to pay for it? I should like to explore these questions briefly, and I am taking the liberty of condensing the text of my statement which was submitted to you yesterday.

Let me interject that I speak from a background of industrial science and the management of industrial research and development. I certainly claim no great expertise on the social, economic, and political aspects of the problem you are investigating. For that matter, it is apparent that the technical aspects of the problem are so broad that no single person can begin to be knowledgeable in all of them. I shall be pleased to try to answer any questions which you may have with the help of Mr. Landon, but I trust you will consider an honest "I don't know" to be the best answer when there are major technical uncertainties or where I have insufficient firsthand knowledge.

So, based on research—particularly industrial research—with which I am familiar, I should like to list some of the areas where I think there are good potential opportunities for finding new knowledge that should be helpful.

DECIDING WHAT THE PROBLEM IS

The continuing interaction of biology, medicine, and other life sciences with chemistry, physics, mathematics, and other physical sciences should help us to define better the true problems of environmental pollution before we spend too much time and energy on the wrong solutions.

For example, I think the time is ripe for some "closed loop" experiments on a large scale. Some of my associates have suggested studies in which constant monitoring of pollutants and suspected pollutants is done over a large populated area. Information from such monitoring would be fed into a large computerized information system. Simultaneously, the computer would be given all possible information about the times and reasons for hospital admissions, reports from medical specialists about the number and severity of cases involving a specific list of diseases and disorders, statistics on absenteeism in school and industry, industrial productivity figures, death and accident rates. We all know the difficulties of establishing cause-and-effect relationships, but certainly if patterns and correlations could be established from such studies, we would have information vital for determining the direction of future research.

NEW MONITORING AND MEASURING TECHNIQUES

Although great progress has been made in building machines that will "sniff" the air and "taste" the water, there is still much to be done.

For example, we don't know enough about the extremely tiny particles that contaminate the air around us. I refer to particles in the general range of a few millionths of an inch in diameter, or less. The surprising fact is that although the particles in air larger than a tenth

of a micron, that's one 250,000th of an inch, constitute some 95 percent of the total weight of all the particles, those smaller than a 10th of a micron constitute some 95 percent of the total number of all particles. More important, the total surface area of these small particles at least equals the surface area of the larger particles. It is on the surface of such particulate matter that waste gases are absorbed, and the fact is that we know little or nothing about how, what kind, or how much gas is absorbed by these tiny particles. Remember, too, that the smaller the particles the more likely they are to get into our nostrils and lungs, and then discharge their contaminants into our bloodstreams. On the basis of their recent work, some of my associates suspect that these mysterious tiny particles may have played an important role in tragic instances of air poisoning such as those in London and Donora, Pa. Surely, we must learn more about them.

SYSTEMS ANALYSIS AND MANAGEMENT

The experience gained by the aerospace and electric utility industries in recent years has produced a new competence in handling multifaceted problems and optimizing systems. The same kind of approach is now beginning to be applied to water-management problems. These certainly can and will be expanded to include a variety of other situations now affecting our environment.

IMPROVED ENERGY CONVERSION AND ENERGY STORAGE SYSTEMS

The U.S. Public Health Service has pointed out that of the "aerial garbage" dumped into the Nation's atmosphere each year, an estimated 85 million tons come from sources under the general heading of transportation. One possible solution to the problem of the internal-combustion engine is, of course, to keep on improving it, with greater emphasis on more complete combustion and cleaner exhausts. You are familiar with efforts in this direction, although it is generally acknowledged that even with the best of luck it may only be possible to keep the present situation from getting worse. In the long run, I believe we must look toward other ways to convert chemical—or other kinds of energy—into mechanical energy.

You have specifically suggested that I discuss the fuel cell in this context.

As you know, the fuel cell is a device that converts chemical energy directly into electrical energy, without moving parts and with inherently high efficiency, since it does not have the Carnot-cycle limitations which put a ceiling on the efficiency of ordinary heat engines. The fuel cell was invented in England, way back in 1839, but it did not have its first practical application until a year ago this month, in the Gemini V spaceflight.

Of course, the success of fuel cells on four Gemini flights hardly means they are ready for automobiles or trucks. At present costs, fuel cell automobiles are economically out of the question.

However, we should not overlook the pace of recent progress in fuel cell research. For over a hundred years there was only spasmodic interest in fuel cells, and virtually no scientific progress. But in the past decade all this has changed. Now, there are literally thousands of scientists and engineers around the world working on fuel cell tech-

nology. A very great deal has been learned, especially since Government-funded programs have accelerated the pace of research and development. If the pace of discovery continues, we must consider that—in the long run—the fuel cell may be a major source of portable power.

Fuel cells have a number of inherent advantages. First they have high theoretical efficiency, which could mean conservation of fuel resources. They are quiet. Most important, from the standpoint of pollution abatement, it is conceivable that fuel cells can be developed that will have no noxious exhaust at all.

What are the problems with fuel cells? As noted, they now cost too much. Some of the most efficient fuel cells work only with hydrogen, an expensive fuel. Then, there is the matter of weight and size—present fuel cells tend to take up more space than we would like.

So, I'll anticipate your question, "When will we have fuel cell automobiles?" And I'll give the answer I promised I might give to some of your questions: "I don't know." I don't know when, and I'm not really sure if.

All I can say is: On the basis of what we know now, fuel cells might someday be very attractive for vehicles because they might not give off any appreciable noxious exhaust, and they might be developed to fit into compact portable packages, and they might be made inexpensively enough for general use in vehicles.

It's a mighty long list of "mights." But fuel cell research has great momentum. The need for alleviating pollution from vehicles is very great. The accomplishments of man, when he puts his mind to it, are being dramatically demonstrated in today's world.

In our own company, we feel that fuel cells are extremely promising for both long-range research and more immediate development work. We're spending a lot of our own money on it, and I don't hesitate to recommend fuel cell research and development to others—including a continuation of support by the Federal Government.

Incidentally, we should not let the glamor and potential of fuel-cell research cause us to overlook the tremendous opportunities for improving electrical storage batteries. An improvement in the efficiency, weight, and cost of storage batteries could have substantial impact on electric vehicular transportation long before fuel cells.

WATER TREATMENT

There is no shortage of ideas in this area. Finding economic solutions is quite another matter. However, I am quite optimistic that intensified effort will produce significant results in the near future. Of utmost importance here, I believe, is that we view the various clean-water problems in proper perspective. Preuse cleaning and afteruse cleaning of water are two substantially different subjects, and there also is a considerable difference between the problems of industrial waste and community waste. Each of these is different technologically as well as economically. A wide variety of solutions will be required.

AIR CLEANING

Also, of course, there is a difference between air conditioning and air cleaning. We believe that new ideas in the electrostatic precipitation of particles, and for removing other contaminants from air, in

combination with more conventional air conditioning, can add to the human comforts now achieved by cooling the inside of buildings; at best, however, such interior air cleaning is only an intermediate step toward the ultimate objective of keeping the outside air clean.

POLLUTION FROM INSECT CONTROL METHODS

Without getting into that argument about "changing the balance of nature," I should like to point out that chemistry is such a versatile and adaptable science that an intensified effort in insect-control research should permit us, in effect, to have our cake and eat it, too. A recent example of a successful chemical effort to eliminate the bad while keeping the good was the solving of the detergent problem: using new chemistry to create the new soft detergents without in any way diminishing their unique cleaning powers. I have every confidence that, with sufficient research effort, it will be possible to improve substantially our health environment through improved "soft" insecticides and alternative methods of insect control.

SEWAGE DISPOSAL

One of the most intriguing ideas stemming from recent research in microbiology is the prospect of using biological processes to convert domestic sewage into two valuable products: water pure enough for drinking, and a high-protein feed for animals. Extensive fundamental research must be accomplished before this prospect becomes practical reality.

COMBUSTION RESEARCH

Unburned fuels are part of our aerial garbage, along with unwanted combustion products. There are opportunities in the areas of altering and improving the fuels used, not only in automobiles, but also in powerplants and countless other industrial and domestic coal- and oil-burning sources of combustion pollutants. New knowledge about basic combustion processes is giving us new hope for simultaneously improving efficiently and reducing unwanted effluents.

In our own company, of course, we are highly interested in central station electric power generating plants of all types: hydro, fossil fuel, and nuclear. Although we do not manufacture the part of the equipment in a coal-burning station which involves combustion products, as major contributors to the total station—through turbines and generators and other equipment—we are naturally concerned about alleviating the pollution potential of the total system.

Thus, we have been actively engaged in combustion research for many years, and we are actively seeking ways to reduce unwanted effluents from the fossil-fuel plants which are the mainstay of today's electric power system in this country. These problems are extremely difficult and complex; much progress has been made over the years, and recently built stations are far superior to older powerplants. Additional progress should be possible, but the economic aspects must not be underestimated.

It is only natural, when faced with the problems inherent in fossil fuels, to think about other energy sources. Hydroelectric power is

wonderfully clean and efficient, although there are sometimes differences of opinion about the environmental aspects of building dams, regardless of the cleanliness of the electric generating process involved. There still remain a significant number of opportunities to install more hydroelectric generation facilities in the United States—and in a manner supporting the objectives of conservationists.

But the matter of greatest interest to those worried about pollution is the news about nuclear power. First of all, economic nuclear power has come of age much quicker than earlier predictions. Nuclear stations are being installed at a rate far ahead of even the most optimistic predictions of a few years ago. It is difficult to overstate the scope and importance of the revolution in power generation we are experiencing right now.

The nuclear news is especially interesting for those concerned with pollution because the cleanliness of nuclear powerplants also has exceeded expectations. There are, of course, no combustion products at all. And the amount of radioactive material emanating from these plants is so small that it is even less than the very tiny amounts of radioactive waste emitted by conventional coal-burning powerplants as the result of radio nuclides occurring naturally in coal.

Well, with a few digressions, I have mentioned nine specific areas of technology where I believe there are opportunities for research that may help in the job of pollution abatement.

Certainly, there are many additional opportunities for research to help improve our envorinment. Those I have mentioned seem particularly important to me because I am aware of research progress in all of them. Success in many of them—if not all of them—seems inevitable.

But I am not at all satisfied that enough research is being done in any of these areas. Which brings us to those two difficult questions: Who is going to do it? And who is going to pay for it?

I should like to make some comments on these questions, but I certainly don't want to suggest that I have all the answers.

It may be helpful to divide the kinds of research opportunities I have been discussing into a smaller number of classifications. We need research aimed at giving us better ways to find out what pollutants are in the air and water—and when—and how they got there. We need research aimed at learning the effects of these pollutants—especially on people. We need research aimed at keeping certain pollutants out of our environment in the first place. We need research aimed at removing pollutants from our environment.

Research in these various classifications of "monitoring," "causes," "effects," "preventive regulation," "preventive technology," and "removal" can be further consolidated, for purposes of this discussion, into two categories:

One, research that will produce information useful for establishing standards, determining necessary regulations, enacting appropriate laws, and suggesting methods; and

Two, research that will produce information useful in developing hardware and system than can be manufactured and sold.

In the first category is much of the needed exploration about the causes, effects, and preventive regulations of pollution.

In the second category is most of the research that should be done in the areas of improved sensing and monitoring techniques, prevention systems and devices, and methods of removing pollutants that can't be kept out of the air and water in the first place.

Government, university, and industrial laboratories can all contribute in all of these areas. But it might seem logical to assign the bulk of the responsibility in the first category to the Government, since much of it concerns very large-scale public health matters, since it is going to be more effective for the Government to coordinate and conduct many of the massive experiments involving large areas of large numbers of people, and since the initial predominant impact of this part of the work will be, by the definition I have used, on the establishment of necessary laws, regulations, and recommendations.

Obviously, university laboratories—with Government support—can make important contributions in much of this work.

In spite of the Government's basic responsibility in this category of the work, the special skills of industrial research can be extremely helpful. Further, the early involvement of industry in all aspects of the pollution problem is essential to pave the way for prompt action once the goals have been set. And, of course, since private industry wants to contribute its knowledge and viewpoints about proposed regulations to combat pollution—especially in regard to the technological and economic feasibility of such proposals—the early and continued involvement of industrial research should be helpful to all concerned.

Industry itself should assume the major responsibility for the research which will lead to hardware and systems needed to monitor pollutants, plus that related to the technology of prevention and removal.

The market for sensing and monitoring equipment should grow substantially in the near future, and I believe industry will be missing an opportunity if it does not substantially increase its research effort here at once. I know one company that is doing so.

In the area of technology for prevention and removal, industry probably will not be motivated to a truly large-scale effort until the "monitoring," "causes," and "effects" research makes it possible to identify the guilty pollutants and quantify the objectives in removing them.

Thus, Government will have to carry proportionately more of the research burden in the early stage of this fight than in the latter stages. Once the necessary rules, objectives, and timetables are established, industry will know better how to channel its efforts. But even as this is being done, and even as the problems are being defined, we should continually remind ourselves that the most desirable eventual solutions will come most rapidly if attacked on a competitive basis. The most economic solutions will be diligently sought by private enterprise, and a profit incentive for those who learn how to do the job best will produce the desired results far quicker than any other approach.

As to who will pay for this research, the same sort of pattern seems appropriate. Industry has opportunities it should explore with its own funds in helping develop the kind of monitoring techniques that obviously are needed now. Similarly, industry should be willing to

invest more right now in the areas of prevention and removal technology where there is no doubt of the eventual need.

But the big surge in industrial research expenditures probably can't be expected until the needed "ground rules" are better established. Thus, we would look forward to a pattern of increased research expenditure by both Government and industry, with the early predominant role of Government tapering off and industry's contribution rising rapidly as the objectives become clearly defined.

I assure you that the company I represent will study the findings of this committee with great care, and we will work vigorously on behalf of making the best contributions we can toward improving the quality of life by protecting and improving the environment in which we work and live.

Mr. DADDARIO. Mr. Miller.

Chairman MILLER. I have no questions. It was an excellent statement.

Mr. DADDARIO. Mr. Mosher?

Mr. MOSHER. It is one of the most interesting statements we have had, and I have no questions at the moment.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. I would like to ask some questions but I know we have another witness coming before us but I hope Dr. Bueche will stay for a few moments to answer questions.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. No question, Mr. Chairman. It is a very fine statement.

Mr. DADDARIO. Dr. Bueche, on page 11 where you refer to the radioactive materials emanating from the nuclear plants, could you give us a reference as to who was involved in this work?

Dr. BUECHE. Yes. It is the work of Merril Eisenbud and Henry G. Petrow referred to in Science, April 7, 1964. These two gentlemen were employed by the Institute of Industrial Medicine at the New York University Medical Center at that time.

Mr. DADDARIO. On page 15 of the Report of the Research Management Advisory Panel, there is a reference to industrial research. Question B1 reads; To what extent can research on pollution abatement sponsored by the private sector of the economy be stimulated by probable markets established by Federal standards? Does the enforcement legislation necessarily depend on previously available technology? You have given us some guidelines. How do feel about how these questions fit in with your concept of the problem?

Dr. BUECHE. First, let me say that I have found this report to be very interesting and very provocative. It has an awful lot of good sense in it. I have considered this question, all the questions as a matter of fact, in some detail and tried to be responsive to them in what I just read.

I think that one of the great stimulants to industrial research or "research sponsored by the private sector of the economy" as it says here, will be the winning of knowledge and the establishment of goals and standards by the Federal Government. I shouldn't restrict this to the Federal Government, I mean Federal, State, and local governments. Pointing up the problem clearly will give the industrial people an assurance that there will be a market. This will bring the com-

petitive aspect forward and I think that the private sector of the economy will do its job once it sees a potential market.

Mr. CONABLE. Mr. Chairman, if we have time, I wonder if Mr. Bueche could say a bit more about item 8 on page 9 of his statement which concerns the prospects for radically improved conversion of domestic sewage to useful products through research in microbiology.

Dr. BUECHE. In this area, I am slightly out of my field, but let me say that we do have a number of biologists and chemists working in the General Electric Co. on this, and they have surveyed for me the various possibilities of treating sewage and have actually started experiments on this.

Mr. CONABLE. Do you have some pilot plants?

Dr. BUECHE. I wouldn't dignify them by the description "pilot plants," but they have done small-scale experiments. Of course, General Electric is not unique in this. I am aware of a number of others who are also pursuing these lines.

Mr. CONABLE. Do you feel there is a possibility of a breakthrough which would be economically feasible?

Dr. BUECHE. I believe it is possible, yes.

Chairman MILLER. Will the gentleman yield?

Mr. CONABLE. Yes.

Chairman MILLER. Isn't much of this being done indirectly in parts of the United States today where reconditioned water is being used?

Dr. BUECHE. I believe it is, sir.

Chairman MILLER. When I told a very distinguished scientist about the plans of the Army for pumping polluted water out to sea in California, he commented that this seemed to be a backward approach. He said that it is time to teach the American people that they have got to use and reuse water. I think this is true even though it may seem distasteful to think about. But it is being done in one of your own plants and I have sampled some of this reconstituted water.

Dr. BUECHE. So have I.

Mr. DADDARIO. Dr. Bueche, you obviously feel that we do have available to us means to solve many of these problems. You have touched on a point which many other witnesses have also mentioned concerning the availability of computers which can be used in these systems and models which you have talked about and which will give us a great impetus. We ought to take advantage of it.

We must begin to combine the efforts of our society. Is there any question in your mind that a great deal needs to be done, even though there is available to us much to do the job with?

Dr. BUECHE. Yes; I think that is correct.

Mr. DADDARIO. From the standpoint of the research that does need to be done, do you believe that our present level of effort is inadequate?

Dr. BUECHE. Yes, sir. That is correct.

Mr. DADDARIO. Dr. Bueche, we recognize how busy you are but we would like to be able to send you some questions for later reply. (Additional questions and answers for the record may be found in vol. II.)

(The biographical statement of Dr. Arthur M. Bueche follows:)

BIOGRAPHICAL STATEMENT OF DR. ARTHUR M. BUECHE

Dr. Arhur M. Bueche is vice president in charge of the General Electric Research and Development Center. He directs the research and development activities of a total staff of more than 1800 men and women, including some 700

scientists and engineers. Dr. Bueche was elected to his present assignment in 1965, when the General Electric Research Laboratory and the company's Advanced Technology Laboratories were combined into a single organization.

Born in Flushing, Michigan, in 1920, Dr. Bueche received his Bachelor of Science degree in chemistry from the University of Michigan in 1943, attended Ohio State University, and was awarded his Ph. D. in physical chemistry from Cornell University in 1947. After serving as a research associate at Cornell for three years, he joined the staff of the General Electric Research Laboratory in 1950. He was appointed manager of Polymer and Interface Studies in 1953 and manager of Chemistry Research in 1961.

As a working scientist, Dr. Bueche became widely known for his work on the physics and chemistry of polymers and the effects of high-energy radiation on plastic materials. As manager of Chemistry Research, he contributed to the success of many scientific projects ranging from improved Man-Made diamonds to selective membranes that behave much like human lung tissue, and from important new kinds of fuel cells to a completely new basic chemical technique called "oxidative coupling".

Author of several dozen technical papers, principally in the area of polymer research, Dr. Bueche also has been awarded 11 patents in this field. He was elected a fellow of the American Physical Society in 1963 and is a member and past chairman of the executive committee of the Division of High Polymer Physics. He is a member of the board of directors of the American Chemical Society and has held numerous other ACS posts, including chairmanship of the Kendall Award Symposium (1957), vice-chairmanship of the Division of Polymer Chemistry (1962), and chairmanship of that division (1963). Dr. Bueche is a council member of the Gordon Research Conferences, was recently named chairman-elect of the Board of Trustees, and is past chairman of the Elastomer Conference. He recently was elected by the Cornell University Board of Trustees to a one-year term as a member of the Council for the College of Engineering. He also is a member of the National Academy of Sciences—National Research Council Committee on Macromolecular Chemistry, a member of the Metals Properties Council of the Engineering Foundation, a member-at-large (Chemistry and Chemical Technology) of the National Research Council, and a member of the Research and Development Planning Council of the American Management Association.

Dr. Bueche's other professional and honorary society affiliation include the National Society of Professional Engineers, American Association for the Advancement of Science, Alpha Chi Sigma, Gamma Alpha, Phi Kappa Phi, Phi Lambda Upsilon, and Sigma Xi. He is a member of St. John the Evangelist Church, the Mohawk Golf Club, and the Mohawk Club in Schenectady, New York. He also is a member of the Susquehanna Valley Country Club, Sunbury, Pennsylvania. Among his hobbies are skiing, golf, and photography.

Dr. Bueche was married December 27, 1945, to Margaret L. Bassler, formerly of Sunbury, Pennsylvania. Dr. and Mrs. Bueche and their four children reside at 1065 Avon Road, Schenectady, New York.

Mr. DADDARIO. Our next witness is Dr. Charles A. Bishop, director of chemical processing and engineering development, United States Steel Corp., and he will be speaking in behalf of the American Iron & Steel Institute.

Dr. Bishop, you may proceed with your statement.

STATEMENT OF DR. CHARLES A. BISHOP, DIRECTOR, CHEMICAL ENGINEERING DEVELOPMENT, APPLIED RESEARCH, UNITED STATES STEEL CORP.

Dr. BISHOP. Thank you very much.

Mr. Chairman, members of the House Subcommittee on Science, Research, and Development, I am Charles A. Bishop, director of chemical engineering development, applied research, United States Steel Corp.; chairman of United States Steel's Air and Stream Pollution Committee; and chairman of the American Iron & Steel Institute's

Committee on Air and Water Pollution Abatement. I am past chairman of the Steel Industry Action Committee of the Ohio River Valley Water Sanitary Commission.

While I appear before you today as a representative of United States Steel Corp., I have been authorized by various other member companies of the American Iron & Steel Institute to make the present statement in their behalf as well. These combined member companies represent approximately 97 percent of the 1965 domestic steel production. I am submitting a list of these companies (see p. 342).

The July 1, 1966, publication of this subcommittee was reviewed in preparing this discussion on the adequacy of technology for pollution abatement, with special reference to the steel industry. The subcommittee is to be congratulated on the breadth of understanding of the pollution abatement field.

Your report, which succinctly expressed many of the views held by the steel industry on the need for new technology, states that:

> Pollution abatement, and indeed waste disposal, costs are a net loss to the gross national product. Greater economy and cost-benefit improvement will often be desirable, even after methods are found which make initial treatment efforts acceptable or economically feasible.
>
> Pollution abatement research and development can also reveal cheaper methods of waste disposal.
>
> Industrial and consumer product recycles, which are developed to lessen pollution, will be important steps in conserving natural resources.
>
> Pollution abatement research and development require an interdisciplinary approach.
>
> Industrial research and development laboratories have already made significant contributions in remedying internal pollution problems.

We also concur that there are areas where additional technology will be required. Your report mentions the gross treatment of mine drainage, control of nitrogen oxide emissions, and sulfur dioxide removal from stack gases.

Research and development efforts have been carried out by individual companies, by groups of companies who find they have a common goal in an area of control, and by sponsorship of the American Iron and Steel Institute. While I will stress the research sponsored by the AISI, due credit must be given to the individual steel companies which have been active in the development and evaluation of new and improved processes for pollution control for many years.

Mr. DADDARIO. Is there any effort being made to combine the work in this field rather than to have it dispersed to individual companies?

Dr. BISHOP. Yes; we have always had very good liaison in the steel industry on our pollution abatement matters, not only in meetings but additionally there is a good deal of visiting back and forth between various steel people. We see each other, I would say on the average of at least once a month throughout the year, and I can assure you that by working together this way we have managed to save ourselves a good deal of time.

Mr. DADDARIO. The reason I ask the question is both because of your statement and because, as I understand it, there is a difference of opinion among steel producers on how to handle pollution. The Fontana plant in California and other independent plants seem to be going down different roads. Is this because they are satisfied that they have the solution, or do they feel they accomplish more this way?

Dr. BISHOP. Companies are familiar with what other people are doing in the field and the different results come about because of different circumstances.

The plant was built in Fontana during the war by the Federal Government. This is an area where there is very little water so they went to extreme measures to conserve water. Most steel plants previously to that had been built in areas that had lots of water. This is normally one of the criteria laid down for building a big steel mill, so the Fontana plant led to a different philosophy.

Senator Muskie one time asked, for example, why Fontana were using a dry precipitator for their basic steelmaking plant while we in the Chicago area were going to use wet cleaners. The answer of course again was that we have lots of water in Gary and Chicago, and can use wet cleaners. In California, with limited water they favor a dry unit. Both will perform with equal effectiveness and I think that is the important point.

When we clean an open hearth for example, the steel industry uses precipitators, wet scrubbers, and one has a bag house. What we try to do is qualify different pieces of control equipment and they compete for service in a particular instance.

Mr. DADDARIO. Aren't these production techniques rather than means to lessen pollution?

Dr. BISHOP. The three I mentioned are cleaning devices that could be used on a given open hearth.

Mr. DADDARIO. Do you believe they are equally effective in the climate under which they are used?

Dr. BISHOP. In one instance you may have a land problem and so this excludes a particular type of unit, or you may have high power costs or some other major factor. The task is choosing the one that is economically superior to do a given job.

Mr. DADDARIO. I am interested in your remark that because we have had a previous suggestion that one possibility would be to establish an industrywide standard. You now point out that this would be a very difficult thing to do because you are operating under conditions that are so different that you must have flexibility as well as objectivity in the standards which are applied.

Dr. BISHOP. That is right, and I feel we have actually made faster progress. As the previous speaker said competition is the spice of life. If you have two or three different methods being developed as possible solutions to a problem you undoubtedly have a much better chance of coming up with an optimum solution.

Mr. VIVIAN. Mr. Speaker, it seems to me that the statement made by the previous speaker, which I concur with, is that if there are no industrywide standards, each industry will determine its own. Industry standards might keep steel mills on the Great Lakes in my own area from paying no attention to the creation of pollution, whereas they may be forced to pay attention to pollution in some other areas.

Dr. BISHOP. You are talking about national standards?

Mr. VIVIAN. National standards for each industry or subdivision.

Dr. BISHOP. Well, it is very difficult, as I say, with the various equipment that has been put in over a period of many years to really come up——

Mr. VIVIAN. Our point is that equipment put in over many years has not been very adequate and therefore national standards will probably be necessary. I would hope that your industry will contribute to make wise and objective standards.

Dr. BISHOP. I have worked, as I point out later in the paper, on the technical committee to the conferees on Lake Michigan in setting up standards there, and I think our industry people have worked along with others in the water quality and air quality criteria.

Mr. DADDARIO. Dr. Bueche, I think it would be helpful since you are here if you could also answer Mr. Vivian's question.

Dr. BUECHE. I think I heard the question, but if Mr. Vivian would care to address the part of the question that he thinks might be applicable, it would be helpful.

Mr. VIVIAN. The question is how can we best use the capabilities of private and industrial research to construct pilot projects and to create the equipment that will eliminate pollution?

It seems to me the best way is to set standards which everyone can work toward in creating the least expensive means of meeting such standards. The question is not to establish standards for New York State, Schenectady, Lake Erie, or Michigan, as you have mentioned, or the ferrous mills at Trenton, but to set a nationwide standard for the minimum amount of effluents that are produced for two reasons: First, it will prevent industry from moving to where enforcement is the least, irrespective of the law; and, second, it will provide those who are designing equipment a more effective market so that they will produce the same quality for different situations.

Mr. DADDARIO. This matter of standards is important because, as I understand Dr. Bueche, one of the important points raised is that once you establish the standards then you do begin to put in proper perspective, the competitive angle without which you cannot accomplish your end objectives.

Mr. VIVIAN. Yes; I agree with that wholeheartedly.

Dr. BUECHE. I will go a little bit further, and I don't disagree with either statement here; that is, rather than call them standards at the early stages one should call them goals or "suggested standards." Then we can see if we can meet these things economically and if we can achieve these goals. Once we find that we can get there, perhaps they should be dignified by the word "standards." But it is quite right; if this is done on a purely local basis, the incentive for industry to contribute will be somewhat lessened.

Am I responsive?

Mr. DADDARIO. That's fine.

Dr. BISHOP. The major industrial contributions to the abatement program lie in the industry's ability and willingness to experiment with commerical-scale plant equipment. You can be assured that the first few installations of control equipment on a process bring many headaches and a few heartaches for the companies involved. However, there is an excellent exchange of information on the operation of control equipment among members of the steel industry, and we learn from each other's mistakes and successes.

The steel industry has been willing to publish the results of its efforts so that other industries can also benefit from our endeavors in

pollution abatement. Also, the steel industry continues to be alert to pollution abatement advances made in foreign countries.

Let us now examine the projects sponsored by AISI.

First, in air pollution abatement.

As Max Howell of AISI reported to the National Conference on Air Pollution in 1958, the institute sponsored work on air-pollution abatement at the Industrial Hygiene Foundation at Mellon Institute for several years starting in 1950. At that time, it was difficult even to define the problem to be solved, inasmuch as simple, effective, and inexpensive instruments which could take a sample which was truly representative of either the ambient atmosphere or of stack gases had not been developed. Therefore, the Mellon Institute group set out to develop instruments and techniques which would be useful in these fields.

Among the instruments developed was an automatic smoke filter which samples the atmosphere for successive short time periods, measured in hours, and permits the tracing of the variations in smoke intensity, largely due to weather, making possible comparisons between different districts, and between different seasons.

A hydrogen sulfide sampler which continuously monitors the atmosphere and an instrument for measuring hourly dust-fall rates with a high degree of precision were also developed. Coupled with the work on the instruments was the development of the techniques required for their utilization. The production and sale of the instruments were undertaken by a commercial instrument maker and, to date, several thousand have been put into use.

At the same time a development program on stack sampling which included the evaluation of techniques for measuring particle size distribution of the recovered dust was conducted.

A training school to which the various members of the AISI sent men to be trained in the techniques used in air-pollution studies was established. The courses ran for 3 months and comprised formal and informal seminars, literature assignments, plant visits, and laboratory work.

In addition to these studies, existing cleaning equipment was critically examined with a view toward classifying it into groups of optimum usefulness. No single device was found which could do all the things necessary to meet air cleanliness requirements.

Therefore, it was decided that an attempt should be made to develop a new type of filter device which, hopefully, would fit into the metallurgical stack gas cleaning program somewhat better than did the conventional cleaning devices. To implement this idea, a research project which is still in operation was set up at the Harvard School of Public Health in 1953, under the late Dr. Silverman. Studies of various filtering devices were made and a new type of continuous self-forming filter made from slag wool was devised.

Three pilot filters were built and tested at an eastern steel mill. Unfortunately, this cleaner turned out not to have advantages over commercially available units, and the Harvard group began the development of an instrument for automatically measuring amounts of dust in stack gases. Final field testing of the unit was conducted this year, and the unit appears to work satisfactorily with the degree of reliability necessary for commercial application.

Since the instrument tested was hand built by the Harvard personnel, commercial production of the monitor is the next stage of the development. The policy of the American Iron & Steel Institute is to publish on such instrument development. Any interested company can then proceed with the manufacturing. It is hoped that the instrument will be referred to as an AISI monitor as the others have been.

The present assignment for the Harvard group is to examine broadly the problem of nitrogen oxides in stack gases.

Battelle Memorial Institute was asked in 1958 to study the mechanism by which fumes are formed in a metallurgical operation and to evaluate possible methods for ameliorating fume formation.

Mr. DADDARIO. Dr. Bishop, do I understand that the three pilot filters that were built and tested, but didn't have economic feasibility led to the development of this instrument to automatically measure amounts of stack dust? You still haven't been able to develop a pilot filter?

Dr. BISHOP. That is right, we have given up the filter development. While it looked promising for a long while it finally was shown not to be an acceptable unit. In working with the unit as a cleaner we became involved in a great deal of sampling and so, as an offshoot of our work, we asked the Harvard group to continue their development work on an automatic monitoring unit, which they have done.

Mr. DADDARIO. Are you still continuing research with the filter?

Dr. BISHOP. No; the filter work has been dropped as being unworkable. We published our results and dropped it at that point.

By chemical and physical measurements and high-speed photography, success was attained in discovering the mechanism of fume formation when using oxygen in a lance in refining steel. It appeared that the inclusion of a reducing chemical with the oxygen might prevent fume formation. In the laboratory, additions of methane, hydrogen, and steam to the oxygen showed considerable promise for suppressing fume formation. However, commercial trials of methane and steam demonstrated that the additives were not very effective and that their use could not be considered as an alternate to the installation of cleaning equipment.

Battelle has now been asked to study the mechanism of formation of hydrogen sulfide from blast furnace slags. When blast furnace slags come in contact with water, they react to form hydrogen sulfide. This is true when cold slag piled in the open comes in contact with moist air or rain. Because hydrogen sulfide is detectable at very low concentrations, it may create a community problem. It is the object of this research to identify the exact reaction mechanisms involved, and then to explore possible ways of economically suppressing the formation of the hydrogen sulfide.

In the water pollution abatement, the American Iron & Steel Institute has sponsored a research project on water pollution abatement at Mellon Institute since 1938 with Dr. R. D. Hoak as administrative head. Emphasis in the program has always been directed toward the accumulation of scientific data that would increase knowledge about the causes of pollution and the measures that could be taken to overcome their effects. A large amount of data on these problems has been accumulated over the past 28 years. Only a few

examples of specific accomplishments can be given here, but they will serve to illustrate the scope of the project.

Recovery of mill scale from flume water has always been a problem in the industry because the finer particles tend to escape capture. Investigation showed that poor recoveries were caused primarily by inadequate design of equipment. Research led to the development of more efficient settling basins. This improved design has been adopted by mill engineers.

Extremely low concentrations of organic compounds can cause flavors in drinking water. It is necessary to identify these substances so that proper steps can be taken to eliminate them. The minute amounts present require that they be concentrated 1,000-fold to obtain enough material for analysis. Highly sophisticated analytical methods are being used to characterize these compounds and to devise ways to overcome their effects.

Accidental spills and pipeline breaks are unpredictable causes of pollution. It is obviously essential that such occurrences be corrected promptly. An electronic monitor has been developed that will signal supervisory personnel whenever there is a marked change in composition so that corrective action can be taken at once.

The control of water pollution is generally a complex problem because of the variety of substances that can be present. One solution is to conduct analytical surveys to identify the sources of the effects in the receiving waters in order to develop appropriate treatment. This is usually a matter of some difficulty because of the large areas involved. Nevertheless, it has been found that highly useful information can be obtained by confining surveys to one limited area at a time and studying that area intensively.

Full and free exchange of technical data is an important feature of water pollution research. This can lead to unexpected bonuses. It has been the experience of the AISI project that results from its research have often become equally applicable to other industries. Cooperation, however, is the key to constructive and responsible research. This can be achieved through candid conferences and punctual publication of scientific findings.

In the early 1950's ORSANCO sponsored a project at the Kettering Laboratory in the Department of Preventive Medicine & Industrial Health, College of Medicine, University of Cincinnati, for the assembly and critical evaluation of information on the undesirable effects of chemical pollutants in water as they relate to man and domestic animals. To assist in the study, the American Iron & Steel Institute contributed to Kettering both money and an abstract service under the direction of Dr. Hoak at the Mellon Institute. The summary tabulations from the ORSANCO-Kettering project have been most helpful.

ADDITIONAL RESEARCH NEEDS

The following areas are those in which the steel industry visualizes the need for additional technological advances over those that hopefully will result from research already underway.

In air pollution abatement it is believed that the work to date on removal of sulfur dioxide from stack gas, though carried out in a competent manner, requires further escalation. In the same cate-

gory are studies on the formation of hydrogen sulfide from the action of moisture on blast furnace slags.

We concur with this subcommittee that no technology is available to deal with nitrogen oxides, if in the future that proves necessary. Research on the control of emission from coke ovens is being accelerated by the steel industry. It appears that most of this experimentation will have to be done on plant equipment.

The first step is to confine the escaping gases and then to clean them. The program consists of an engineering evaluation of industry and suppliers' ideas, installation of devices on commercial equipment, followed by evaluation of the good and bad features as well as the effectiveness of the devices. Further changes are then made as indicated.

In water pollution abatement technical advances would be most welcome in the treatment of mine acid discharges and in the development of methods for slowing down or stopping the formation of the constituents found in mine water discharge.

As you know, the control of ammonia and other nitrogen compounds is often discussed in dealing with excess nutrients going to receiving waters. The steel industry is faced with large volumes of plant discharges containing a few parts per million of ammonia. No economically practical system for treating such wastes is known.

A particularly thorny problem arises when chlorides are discussed since no practical method for removing them is known.

I served on the Technical Committee to the Conferees of Lake Michigan to recommend water quality criteria. Research needs are listed in the report of this committee. The first is to obtain a better understanding of the causes of eutrophication.

While it appears to many that a limitation on the phosphate content holds the best promise for reducing the rate of eutrophication, actual limits are in doubt. Although the Conference dealt mainly with protecting Lake Michigan waters, many streams suffer from eutrophication. In a recent paper by McDonnell and Koutz, "Algal Respiration in a Eutrophic Environment," JWPCF, 38, 841 (1966), linear regression analysis was used to determine the primary factors affecting the dissolved oxygen resources in Spring Creek. This stream in central Pennsylvania is characterized by excessive plant and algal growth. The waters of Spring Creek receive the completely treated effluent from the sewage plant serving Penn State University and the surrounding community. Several fish kills and the gradual deterioration of reaches of the upper stream prompted an investigation of the ability of Spring Creek to assimilate organic pollutants imposed by the sewage plant effluent. It was demonstrated that the biological oxygen demand (BOD) remaining in the treatment plant effluent had little if any effect on the depletion of dissolved oxygen at the critical stream sag point. Excessive algae are evidently the culprits.

The authors believe the solution lies in the removal of nitrogen and phosphorus from the effluent. For Spring Creek further investigation is required to answer the question of how much removal of nitrogen and phosphate is necessary. Is it possible that control of phosphate alone would solve the problem? I feel certain that many streams should be studied in a similar manner to Spring Creek in order that the correct control measures may be applied.

The Lake Michigan Technical Committee report also stated that the area dealing with threshold odors needs intensive research. It is the belief of the steel industry, based on laboratory and waterworks data, that phenol has too often been blamed for threshold odor problems caused by other constituents. Last July, as a result of my work with the Lake Michigan Technical Committee, I recommended a joint research program between personnel of HEW and the AISI research group under Dr. Hoak at Mellon Institute to investigate the formation of chlorophenols from chlorine and phenols in the very low concentrations that occur in sources of water supply. This joint research program has not been started because of administrative changes in forming the new Federal Water Pollution Control Administration.

The final area covered by the technical committee is the need for epidemiological studies on bacterial pollution. The relation of bacterial contamination to incidence of diseases among bathers never has been established scientifically. Research on a vast scale would be required to provide such a scientific basis.

As a matter of fact, a British publication came along some years ago and said it was safe to swim in sewage plants.

I trust that the foregoing has summarized the research being sponsored by the American Iron & Steel Institute, the type of activities being undertaken by the individual steel companies and the research needs as they can presently be visualized. As water quality criteria are announced by the various States, additional areas for technological improvement and advance will be evident.

(The list of companies on whose behalf the testimony is presented is as follows:)

COMPANIES ON WHOSE BEHALF THE TESTIMONY IS PRESENTED

Alan Wood Steel Co.
Allegheny Ludlum Steel Corp.
Armco Steel Corp.
Atlantic Steel Co.
Bethlehem Steel Corp.
CF&I Steel Corp.
Columbia Tool Steel Co.
Crucible Steel Co. of America
Erie Forge & Steel Corp.
A. Finkl & Sons Co.
Florida Steel Corp.
Granite City Steel Co.
The Hanna Mining Co.
Harrisburg Steel Co.
Inland Steel Co.
Interlake Iron Corp.
Jessop Steel Co.
Jones & Laughlin Steel Corp.
Kaiser Steel Corp.
Keystone Steel & Wire Co.
Laclede Steel Co.
Latrobe Steel Co.
Lukens Steel Co.
McLouth Steel Corp.
National Steel Corp.
Northwestern Steel & Wire Co.
Oglebay Norton Co.
Pickands Mather & Co.
Pittsburgh Steel Co.
Republic Steel Corp.
Sawhill Tubular Products, Inc.
Sharon Steel Corp.
Shenango, Inc.
Southern Electric Steel Co.
United States Steel Corp.
Valley Mould & Iron Corp.
Washington Steel Corp.
Wheeling Steel Corp.
Wyckoff Steel Co., Division of Screw & Bolt Corp. of America
The Youngstown Sheet & Tube Co.

Mr. DADDARIO. What is the total amount invested in research each year?

Dr. BISHOP. I really don't know. Our AISI work varies depending on projects, at about $400,000 per year. The company research is very difficult to estimate. There is a gamble on trying out some new

ideas. We have precipitators that have lasted 4 months before they had to be taken out of service and destroyed, so I think it is a very difficult number to come up with.

Mr. DADDARIO. Do you think you could come up with an estimated figure, considering all of the companies listed?

Dr. BISHOP. We will certainly be glad to do that.

Mr. DADDARIO. So we might be able to come to some judgment about overall effort.

Dr. BISHOP. Yes.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I would like to ask that those figures be broken down as to on-going research and the nonrecurring type.

(The only estimate available as to the information requested is as follows:)

[Extract from p. 3, the U.S. Steel Quarterly, Aug. 1966]

An estimated $200 million out of some $5 billion that U.S. Steel has invested in new facilities during the past 15 years has been committed to the installation of devices for the abatement of air and water pollution—devices that in some cases tower nine and 10 stories high, in others occupy tracts the size of a city block, and in most cases involve operating and maintenance costs of no mean proportions.

The new facilities encompassed in the corporation's current program, which calls for average annual expenditures in excess of $600 million during the three-year period 1966–68, will incorporate, as part of their basic design, the latest air and water quality-protection equipment devised by modern technology.

The outlays, past and prospective, for the apparatus of air and water quality-management are in pursuance of U.S. Steel's continuing objective in this field: *To strive to curtail the impairment of air and water that is inherent in the corporation's operations and that affects the usefulness of these resources by the plant-community neighbors of U.S. Steel.*

Mr, Chairman, I have a number of questions.

Mr. DADDARIO. Why don't we take about 5 minutes, Mr. Vivian.

Mr. VIVIAN. How do you decide specifications for new steel mills? What specifications are provided by the Government for steel mills in the treatment of pollution?

Dr. BISHOP. For new steel mills you normally have a regulatory agency that you work under. In the case of water, it is the State agency. In the case of air, it is either the State or local agency. They normally set up the criteria that are going to be required for the operation of the water and air pollution facility for the new mill.

Mr. VIVIAN. Does this take into account enforcement? I find that standards and enforcement are two separate words. Do you find differences in enforcement throughout the country?

Dr. BISHOP. We are all human beings so I think the answer is that there would be some differences, but the water pollution group, for example, are at least beginning to get together as a result of the 1965 Water Act, which calls for the States to set up water quality criteria, I believe between now and next July. I think this is going to bring more uniform requirements.

Frankly, we find regulatory people are interested in their enforcement programs and they are interested in getting pollution cleanup done.

We have large equipment. We can't move—you mentioned the possibility earlier, from one area of the country to another. I think that

most big industries just couldn't do it, so this is not a factor in our consideration.

Mr. VIVIAN. How about rebuilding old mills? Many a steel mill is quite old. There is a tremendous capital investment involved. I can remember several that I have been through that have been unchanged for 50 years. What do you do with these mills? Do you bring these up to date by applying new standards for replacement of the old mill?

Dr. BISHOP. In most instances we have been able to replace old facilities with new facilities in a given area. In cases where like open hearths that even though they may be 30 years old, we intend to use them another 20 years and we put cleaning equipment on those. If the open hearths are very old, we may replace the whole shop with a new basic oxygen steelmaking shop, so each case must be figured on its merits.

Mr. VIVIAN. Your comments about Spring Creek were very pertinent. To simply raise the question is very useful in itself.

Dr. BISHOP. Fine. Thank you, I thought it was a most interesting piece of research, which broadens the 1925 work of Streeter. Life is becoming more complicated now and the old work is still good, but new ideas have to be added to it.

Mr. VIVIAN. Mr. Chairman, I would like to ask Mr. Bueche a question regarding the storage battery situation. There are some now used in space vehicles. Can they be used in conventional automobiles?

Dr. BUECHE. I think electric power will certainly be used in the future for some vehicles, but not all. The difficulties with the batteries we have today are matters of cost, size, weight, and cycle life. They just don't last long enough for the day-to-day use that you would like to put them to. So the answer to your direct question is no, we won't use the ones we are now using in space vehicles for vehicular transportation in the near future.

On the other hand, there are many opportunities for improving the performance of batteries using different systems—for getting lower cost, lighter weight, and longer cycle life. I am personally very excited by this.

Mr. VIVIAN. If we were to raise the gasoline tax in order to reduce the amountof pollution, would this increase the use of batteries?

Dr. BUECHE. I think it would in commercial vehicles—milk delivery trucks and things of this sort. I doubt that it would have very much effect on private transportation, but you are a better judge of that than I am.

Mr. VIVIAN. You mentioned new electrostatic air conditioners. Are there significant new changes being made to clean up the air coming into the home?

Do you see a massive change in the utilization of these devices so that it will affect the whole pollution pattern?

Dr. BUECHE. Perhaps I should say "no" on the scale that your statement implies. But we hope that there will be considerable market for these devices.

(A brief biographical statement of Dr. Charles A. Bishop follows:)

BIOGRAPHICAL STATEMENT OF DR. CHARLES A. BISHOP

Charles A. Bishop: B.S. Chemical Engineering, University of Kansas (1936); Ph. D. Chemical Engineering, University of Pittsburgh (1942); Mellon Institute Fellow (1936–1941); Associate Professor of Chemical Engineering, University of Pittsburgh (1941–1946); Director, Chemical Engineering Development, United States Steel Corporation (1946–date).

Mr. DADDARIO. I want to thank all the witnesses today for their excellent presentations.

This committee will adjourn until 10 o'clock in the morning at this same place.

(Whereupon, at 12:15 p.m., the committee was adjourned to reconvene at 10 a.m., Wednesday, August 10, 1966, at the same place.)

THE ADEQUACY OF TECHNOLOGY FOR POLLUTION ABATEMENT

WEDNESDAY, AUGUST 10, 1966

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The committee met, pursuant to adjournment, at 10:08 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. George E. Brown, Jr., presiding.

Mr. BROWN. The subcommittee will come to order.

In the absence of Mr. Daddario, I have had thrust upon me the honor of opening the meeting here this morning. We will call the first witness, Dr. MacLeod, Deputy Director, Office of Science and Technology.

Dr. MacLeod, we are happy to have you here this morning. You may proceed at your pleasure.

STATEMENT OF DR. COLIN M. MacLEOD, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY

Dr. MACLEOD. Thank you.

Mr. Chairman and members of the committee, I'm very pleased to be given the opportunity to testify before this committee this morning on some of the questions that relate to pollution of the environment. I have provided a statement to the committee and for that reason I shall confine my remarks to a brief summary of some of its contents and a few additional observations in amplification of some of the observations contained in the submission.

This committee has had extended testimony by various people who are concerned with problems of pollution. It is now apparent that almost all segments of our society are concerned with the ill effects of pollution and that there is a growing national determination to restore damage that has already occurred to our natural environment as well as to prevent further degradation.

We shall never restore the primeval wilderness that our forefathers saw and we shouldn't expect to, but we can prevent further encroachment and restore much of the damage that has been done. However, we must all remember that this is going to be exceedingly costly. To understand the magnitude of the problem we should recall that the production of solid wastes per city dweller per year is about 1,600 pounds and this does not include the great variety of other wastes such as sewage, automotive effluents and industrial and agricultural

wastes. Any increase in the standard of living has as a concomitant, increase in waste production.

One of the measures of the quality of our civilization must be our concern about preserving and restoring the quality of our environment, not only for our own benefit, but because we are the dominant biological species.

We have a clear responsibility to damage nature no more than is necessary for our material and spiritual progress.

I'm very pleased by the change of attitudes toward problems of pollution in the last few years. We have taken the first steps in the broad awareness of its undesirability. We have not faced up yet, sir, to the tremendous costs involved in abatement and restoration nor to how these costs are to be paid.

Some of the costs are for the general introduction of well-known principles and practices of sewage treatment so that we don't further damage our streams, our lakes, our estuaries and even the oceans themselves.

Great progress can be made with what is now known. However, we need greatly improved methods of tertiary treatment for sewage and this will cost a great deal in terms of research, development, demonstration, and widescale use. We also need improved methods for the removal and prevention of industrial byproducts now discharged into streams and into the atmosphere.

Likewise, we know a great deal about how to reduce the noxious effluents from motor vehicles, but we must go much further in the design and development of alternative methods of vehicular propulsion if a long-term solution is to be found. One of our consultants, in discussing the new standards for automotive effluents in the State of California, particularly in the Los Angeles region, has pointed out that—even with reduction in effluents that will come about as a result of new standards that have been introduced—with the increase in the number of motor vehicles that is projected we will be by the year 1980 about as badly off as we are now.

We need to develop new pesticides that are much more degradable than many of those that are in use.

We need to know a great deal more about the toxicity of chemical substances that we are exposed to in low dosage over long periods of time in the normal course of our lives before we can set reasonable standards to govern our exposure to them.

We need to develop much more sensitive automatic devices to monitor pollutants of all kinds so that we can have current awareness of what is going on.

Most of the problems of pollution are extremely complex and require a systems approach for their solution. It is necessary, therefore, to employ all the modern means of systems analysis, including automatic data processing, in order to have a proper understanding of how a particular question should be tackled and how it should be solved. We must understand also how modern industrial man is changing the total environment of the earth, not only for himself, but for all living things whether they be plant or animal. We must remember the slowness of the genetic mechanisms to accommodate to the changes that we introduce into nature.

In my prepared statement, I have referred to some of the major ecological changes that are in process now because of human activities. A notable example is the projected increase in atmospheric carbon dioxide due to the consumption of fossil fuels that were deposited millions of years ago. Here we deal as well with the depletion of irreplaceable natural resources.

At our present and projected rate of burning of fossil fuels—coal, oil, and natural gas—during the next 35 years, it seems possible that there will be a buildup of carbon dioxide in the atmosphere sufficient to cause a modest but significant rise in atmospheric temperatures over the whole earth. This is the so-called greenhouse effect.

This modest rise in temperature could cause very large changes in vegetation. It might cause melting of the polar ice caps, with the levels of the oceans rising and unprecedented effects on all living things.

A great deal of research on this is necessary to understand what changes might occur and also how they might be prevented.

It might also be suggested that we avoid the possibility of these changes in the future by the vigorous development of other sources of energy such as nuclear power, solar energy, and the gravitation energy of the tides.

At the same time, over the long term, we would be preserving these precious hydrocarbon resources for what may be their highest use as industrial raw materials.

It is apparent, I believe, that large scale imaginative R. & D. efforts are required and that the total system needs to be examined, not just segments of it. Lately, concern has also been expressed about the stability of the oxygen in our atmosphere. The oxygen in the atmosphere is derived from the photosynthetic processes of green plants, on land and in the oceans. The latter source, which consists of the minute green plants called phytoplankton, contributes a significant amount of the atmospheric oxygen that we breathe, variously estimated as equal to or as much as 10 times as much as that produced by the terrestrial plants.

Concern has recently been expressed that the dumping of poisonous substances into the seas such as insecticides, herbicides, and industrial wastes may diminish plankton population and hence oxygen production. If this were to occur—and I should emphasize that we don't know yet whether this is a real threat—there would occur a gradual decline of oxygen in the atmosphere with drastic effect on all living things. This would be over a time span which is long in terms of man's life but short in terms of geological time.

The oxygen lifetime in the atmosphere is around 2,000 years.

I must emphasize again that the reality of this threat is not known but we must understand its implications. This will require a good deal of investigation, including an understanding of the effects of toxic chemicals on the green plants of the sea, the phytoplankton, and the long-range accurate monitoring of the oxygen in the atmosphere.

While increased expenditures are necessary to apply what we already know to pollution abatement, it is also apparent that we need to develop a great deal of new knowledge. I have indicated some of the areas, only a few of them, where new knowledge is required. This

will involve new expenditures for research and important emphasis on the training and education of the men and women who are needed to tackle the ever-increasing problem of pollution and its effects.

In the last approximately page and a half of my prepared statement, I have summarized some of the activities of the Office of Science and Technology that are concerned with problems of pollution, and I invite you to turn to page 14. Since its establishment in 1962, the Office of Science and Technology has been concerned actively with pollution problems. The President's Science Advisory Committee report on "Use of Pesticides" was published in 1963, and since then our Office has assisted in the development and in the activities of the Federal Committee on Pest Control. There are also related reports: that on "Cotton Insects" of 1965 and on "The Handling of Toxicological Information" in 1966. The Federal Council for Science and Technology's Committee on Water Resources Research has devoted considerable attention to water pollution. The recent report of the President's Science Advisory Advisory Committee entitled "Effective Use of the Sea" includes attention to marine pollution problems. The recent report of the President's Science Advisory Committee, "Restoring the Quality of our Environment," which was published early last winter, is devoted broadly and extensively to the subject of pollution. It includes numerous specific recommendations that pertain to control.

An assessment of the responses of the various agencies to that report has just been completed and plans are actively afoot for further implementation, including, where necessary, coordination of related activities in Federal agencies.

Pollution problems, as I really need not remind you, are closely related to our national concern for the preservation of natural beauty.

The Office of Science and Technology and Bureau of the Budget are now completing a study of how the Federal Government can best help to advance our understanding of natural plant and animal communities and their interactions with man. The results of this study, we believe, will contribute information and recommendations which should be useful to support an advanced program needed for pollution control. There are a number of other activities of an on-going nature which our office is intimately concerned with, such as the Federal Radiation Council.

In the future, the Office of Science and Technology will continue to provide leadership and to conduct evaluation and coordinating actions among the Federal agencies to develop policies and programs which are aimed at improving the control of pollution of the land, in the air and in the water; which will advance our capability to restore degrading environments, and protect important natural systems which have not been yet spoiled by man.

Thank you, Mr. Chairman. That concludes my testimony and I will be pleased to attempt to answer your questions.

Mr. BROWN. Thank you, Dr. MacLeod.

Your testimony has been extremely useful.

Mr. MOSHER. Dr. MacLeod, on page 7 of your statement, you say that we do not have sufficient information to develop methods to control overfertilization of our waters, and lower on that same page you refer to the necessity to develop tertiary sewager treatment systems.

Because of the location of my district, I happen to have a special interest in Lake Erie.

Dr. MacLeod. Yes, sir.

Mr. Mosher. On August 3, Mr. William Warne, director of the California Department of Water Resources, testified that his State is constructing a prepilot treatment plant to study ways to remove excess nutrients in the runoff of fertilizer from agricultural lands and in sewer wastes.

I think that in the Lake Erie area this runoff from fertilized agricultural land is an important and critical matter. In this prepilot plant, they hope to extract the nutrients from the drainage waters by growing algae in the water and then removing this algae from the water, thereby removing the nutrients that were utilized in the growth.

In California they are developing this prepilot plant to try to solve the problem that way. Do you think that this process has a possibility of application in an area as large as the Lake Erie area? Would you see practical possibilities there?

Dr. MacLeod. Part of the problem with Lake Erie, Mr. Mosher, is due to runoff from agricultural lands but a great deal of it is due to the dumping of raw sewage, sewage that has only had primary treatment, and sewage that has had secondary treatment into the lake.

Mr. Mosher. I'm sure that's correct.

Dr. MacLeod. This has been verified, sir. I should think that the first steps would be to have adequate treatment of sewage in all the communities that border Lake Erie, both on the United States and the Canadian sides. As a part of that treatment, one would hope that we would be able to develop efficient methods of tertiary treatment, of which the one that Mr. Warne cited for you is an example. It is probably a very good example because the algae in the course of their growth do take up these soluble nutrients—the phosphates, potassium and nitrogen that are in soluble form in sewage and which, of course, run from the land. And if algae can be grown efficiently and harvested, this should be one of the methods that could be efficiently applied to tertiary sewage treatment. It is in the development stage as you have said, but the principles I think are understood. We need to devote a good deal of further effort to completing the development and demonstration of the processes. It is possible there are other methods that could be used—methods that, for example, one might apply to the removal of salt from saline waters might also be thought of in this matter.

I think there has to be an approach not from just one avenue but more than one.

Mr. Mosher. What about the correction of some of the damage that has already been done; for instance, the overgrowth of algae that exists? What practical possibilities are there for its removal in a body of water as large as Lake Erie?

Dr. MacLeod. I am afraid I can't answer you, sir. I can't answer you directly but I think if we can prevent overfertilization of the lake, and if fish and other living things can survive in the numbers in which they formerly existed, in terms of their consumption of the foods that are there now and the fishing from the lake, then in the

course of time one might be able to restore partially at least the quality of Lake Erie.

Mr. MOSHER. To whom would I go for the best possible current answers to these questions? If you have any suggestions, it will be helpful.

Dr. MACLEOD. I believe the people to whom you should go are the Federal Water Pollution Control Agency, now in the Department of the Interior, but formerly in Health, Education, and Welfare.

Chairman MILLER. I was just going to make an observation. We brought part of this problem on ourselves because we were unable to keep up with some of the problems that presented themselves. In my estimate, Congress itself is partially responsible because we allowed a single problem to be broken up among many of the committees of Congress and then it became departmentalized even further. Each fellow had his job to do and he did his job but we didn't look to see what the connections between the various areas were. I remember when we passed bills to appropriate money for sewage disposal we said, "This is a great thing—look at the strides we are making," but we failed to take care of the effluents. Now, we are paying for it.

I'm conscious of the fact that a powerplant in the State of Washington is using water from the Columbia River as a coolant. The water was not contaminated, but its temperature was raised a little over 2° and the salmon beds were destroyed in that part of the river.

So, one of the things we are interested in is to see how we can develop the coordination that will eliminate some of these abuses.

While we are talking about contamination, I must mention the fact that we are using the sea as a great sewer and a place to get rid of all our refuse.

I had the privilege of being chairman of the first Subcommittee on Oceanography. We made up a report on the disposal of atomic waste on the Atlantic and gulf coasts. We studied this report and made some rather deep comments on it. They never have succeeded in getting a report filed for the Pacific coast, because by the time we got into this, the interested agencies, particularly the conservation agencies in Oregon, Washington, and California, began to protest. Then in California, the division of fish and game reproduced the containers that the Atomic Energy Commission planned to use to dispose of the waste. It was supposed to be disposed of in a thousand fathoms of water but it turned out that these containers caved in at about 400 fathoms.

Sooner or later, we are going to have to harvest the sea instead of contaminating it. Shouldn't we be looking now to see what the effects of these things are going to be in the sea?

While we are trying to correct the conditions that exist in the inland waters, we have to look beyond that. I'm conscious of the fact and perhaps you are, that the British Government is dumping some pretty high level atomic waste into the North Sea. There's a countercurrent under the Gulf Stream. What will happen to the shellfish if enough of this gets into the sea and runs on to our own northern coast?

The Japanese did some research work. They hired the Picards to make a study for them and found up-wellings of sea water where they didn't expect to. This caused them to make some specific changes in

plans that they had for certain atomic developments because of this waste problem. So I think it is fine to do these things. I think we have to work harder on these problems than we have in the past. Many people knew and saw these things coming but they were voices in the wilderness.

I think right now the very fact that we are interested in Lake Erie, or I'm interested in the pollution of the inland waters of California, is a good thing because others will become more conscious of the problem. I would like to make that observation and see whether you agree with it or not.

Dr. MacLeod. Chairman Miller, indeed I do agree with what you said. In the examples of very large scale effects that may be occurring, I did not choose the sea, but I might just as well have. The examples I used concerning the production of carbon dioxide and the raising of carbon dioxide in the atmosphere and the possible depletion of oxygen from the atmosphere could just as well have been exchanged for the oceans themselves. We don't have an understanding of what we are doing when we are dumping wastes of all kinds into them and they are not the inexhaustible sink that used to be thought of.

We know that, particularly in the estuaries and in the coastal regions, there is extensive contamination. We don't know yet how significant this is in the broader reaches of the ocean. However, I should recall that penguins in the Antarctic are already demonstrated to have had it in their fat. How it got there we don't know, but the fact of its presence seems to be incontrovertible.

This seems to indicate some very widespread contamination in creatures, with the same biochemicals.

Mr. Brown. Mr. Conable?

Mr. Conable. I would like to ask a few questions about carbon dioxide level in the air. Does this result in the striking of a new balance? Does it encourage the growth of new green plants in which photosynthesis can occur? Is this one of the reasons we get the so-called greenhouse effect?

Dr. MacLeod. I will attempt to answer those, sir.

With an increase of carbon dioxide in the atmosphere, there will be some increase in photosynthesis with uptake of carbon dioxide. However, the increase in carbon dioxide uptake by the photosynthetic plants might not be nearly enough to compensate for the great increase that has been put into the atmosphere.

Now, as to the greenhouse effect, if I might explain that very briefly. The sun's radiation falling on the earth comes through a blanket of carbon dioxide and the visible light comes through very easily. However, carbon dioxide in the atmosphere has a very definite effect on holding down the infrared radiation—the heat radiation that goes back up—so that if you increase the content of carbon dioxide in the atmosphere you prevent the dissipation of heat from the earth's surface. Therefore, the heat rises, and this is why it is called a greenhouse effect.

Mr. Conable. Is there already a demonstrable increase in the carbon dioxide content of our atmosphere?

Dr. MacLeod. There have been some studies that indicate it. I wish that the information were better than it is, but the problem is

that accurate measurements have not been available over a long enough period of time so that one can really say there is a trend that is unmistakable.

Mr. CONABLE. Other things remaining constant, then, we don't necessarily strike a new balance by increased plant growth. The carbon dioxide content could get far ahead of the increased photosynthetic capability of our foliage. There are other factors that might be at work in this such as the urbanization of our society which causes a great deal of our landscaping to go back to forest and this, therefore, increases the amount of photosynthesis actually going on. Is that a fact?

Dr. MACLEOD. I don't know in quantitative terms how much that amounts to. I think one should remember, however, that the largest sink, if I can use the word, for carbon dioxide is the oceans. The phytoplankton, the small green plants that grow there, also take up carbon dioxide and carbon dioxide is also removed by the weathering of rocks and release of salt such as calcium and magnesium which combine with it and then are washed into the seas.

Mr. CONABLE. Could the increase in the carbon dioxide content in the ocean add to the atmospheric content?

Dr. MACLEOD. The solubility of carbon dioxide in sea water is not enough, sir; I don't think, to make a significant difference.

Mr. CONABLE. It would not be likely to have secondary atmospheric effects?

Dr. MACLEOD. I don't think so.

Mr. ROUSH. This discussion concerning carbon dioxide reminds me of an experience I had last fall. I was in Ethiopia and I visited a class being conducted by a Peace Corps teacher, named Mrs. Miller, who was very vivacious and imaginative. It was a class in science and Mrs. Miller was teaching seventh graders about protons and electrons. She drew a picture of two rooms on the board. There was a door between the rooms, but she emphasized the fact that the door was closed. She said, "Supposing we put 200 people in one room and in the other room we put no people, what would happen?" There was a look of amazement on these bright-eyed youngsters and, finally, one little boy dared to raise his hand and he said there would be much carbon dioxide and they would all die.

Do you think there is a danger that there will be so much carbon dioxide that we will all die someday?

Dr. MACLEOD. No, sir; I don't believe so. The amount that could be produced from the consumption of the fossil fuels coupled with the rate of removal is not enough so that we would all die, but the accumulation in the atmosphere could very well have these undesirable effects which I referred to here and which I discussed with Mr. Conable.

Mr. ROUSH. In your statement, you emphasize the fact that we have no long-term plans to deal with the problems associated with carbon dioxide buildup in the atmosphere. You go on to say it is time that our Nation began to work diligently toward a goal of recycling fuels and of utilizing natural energies. It would seem to me that even if this Nation did this, the carbon dioxide problem is one that confronts the entire world since the atmosphere is involved. Do you know of any other nations which might be directing their thought and energies toward this problem?

Dr. MACLEOD. Well, Mr. Roush, the contribution of the United States, for example to carbon dioxide output, is a very large one indeed because of the size of our country and because of our enormous consumption of power.

Other countries, particularly the other industrialized ones, submit their share also but ours is by far the largest single contribution.

I am not aware of any concerted national efforts of this kind in other countries nor am I aware of any international efforts. There could be and I would not know of them, sir.

Mr. ROUSH. Is there any organization which might make possible an interchange of ideas about the problem?

Dr. MACLEOD. Yes, sir.

Talking about particularly the advanced industrialized nations or some of them, through the Organization for Economic Cooperation and Development which is headquartered in Paris, one has 22 of the advanced nations that are members. That Organization has in the last 3 years taken a much greater interest not only in the problems of science itself, but is also beginning to have an interest in problems of pollution.

Dr. Buckley, who is here from the Department of the Interior, for example recently attended a conference in Paris on problems of pesticides and their inadvertent escape into the environment. So there is a beginning interest, but I must emphasize that it's early as far as this organization is concerned.

Mr. ROUSH. Is this a permanent organization with a permanent staff and permanent participating members from various nations?

Dr. MACLEOD. Yes, sir; it is a permanent organization.

Mr. ROUSH. And whom from the United States, or maybe I should say what agencies, are members of this Organization?

Dr. MACLEOD. Well, as far as the total organization is concerned, there are representatives from many of our agencies depending upon the subject—whether it be agricultural policy or monetary policy or whatever.

In the science policy activities of OECD, for example, I have been the representative from the Office of Science and Technology. And Mr. David Beckler, also from our Office, has been the representative to a Committee on Research Cooperation.

These activities are moving forward, but I think there is a long way to go and I could not give you an optimistic statement about how long it is going to take to do this.

Chairman MILLER. Will the gentleman yield?

Mr. ROUSH. Yes.

Chairman MILLER. Isn't cognizance of this problem stimulated partly through scientific attachés we have in these countries? Aren't they in contact with foreign experts who are interested in this problem?

I was in Europe for a meeting of the Committee on Peaceful Uses of Outer Space recently and came back through Bonn where I had an hour's discussion with Dr. Stoltenberg. We didn't talk to him about these things, but in talking before I sensed that the Germans are beginning to take cognizance of some of these pressing problems. After offhand conversations with our people there, I believe they

are becoming particularly concerned with the pollution of the Rhine River and are studying this rather carefully, are they not?

Dr. MACLEOD. Yes, sir; they have been under study for really quite a long time. Perhaps on some tributaries of the Rhine as effectively as any studies have been carried out on the problem.

I don't want to go into the details of it at the present time, but they have even had in operation for quite some time a system of effluent charges for those who pollute. Those who pollute pay in proportion to their pollution of the river.

Chairman MILLER. This might be something that we should consider in regard to most of our rivers and the people who pollute them.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON. Your comments about excess carbon dioxide make me wonder whether we shouldn't look at the effects of different quantities of various materials, chemicals, and elements in the ecological process so that we can get a process approach rather than a static time or dumping approach. I understand it took man a million years to attain a population of 1 billion people. The second billion took 15 years. The third billion took 10. It is taking us about 7 years for the fourth billion. We could reach a point where we get instant billions of people—where there would be another billion every 90 days or every month. Now, that brings up the question of a process and of how the human race can best exist in an ecological process and environment.

Maybe we should be looking for the uses of the extra carbon dioxide. Or maybe we should look at the waste as source material in a process rather than an end result. Would you comment shortly on that?

Dr. MACLEOD. Yes.

I am in total agreement with you on the point of a dynamic versus a static approach to these problems. I think one should go a little further and say we need to take a total systems approach.

Mr. FULTON. That is what I am talking about, a process.

Dr. MACLEOD. Not just the pieces of it but the whole process, and not only what influences cause it but what we can do instead to prevent it. I believe fully that we have to have this total systems approach to these problems of the environment and the ecology. As far as using up more of the carbon dioxide in the atmosphere to take care of the increasing population, I don't think that will be a very significant consideration, sir. I think we had better perhaps look for other methods of control.

Mr. FULTON. What I really mean is couldn't you get products from carbon dioxide that would be very useful? Carbon and oxygen are in most of the materials that we use. Wouldn't that be possible? Couldn't we put the elements carbon and oxygen to constructive use rather than just considering them waste material? That's my point.

Dr. MACLEOD. This is being done through the process of nature all the time, sir, and really remarkably efficiently. We use just these elements, of course, in chemical synthesis of one sort or another. Nature, however, provides to date the most effective and cheapest method of putting these elements together and making products out of them that are useful for our survival.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. I have no questions.

Mr. DADDARIO. Dr. MacLeod, it is nice to have you here and I regret that I had a meeting that went past 10 o'clock so I didn't have a chance to be here for your full hearing. I would like to have you describe the coordination of pollution research and development among the Federal agencies. How does it look to you at the moment? Are we doing a good job or do we need to do more? Should the Department of the Interior take over more of these responsibilities? Is it going to be the lead agency? Should we look to it for guidance and control over these coordinating problems, if any exist?

Dr. MACLEOD. Mr. Daddario, our activities in the Office of Science and Technology, as I mentioned earlier, go back a number of years and I suppose have been in part guided by not only our increasing awareness of the magnitude of the problem and what needed to be done but the general awareness of these needs. I think perhaps in the last 2 or 3 years, for the first time, one has the feeling that we are going to mobilize the resources that are going to be necessary in order to abate and restore—abate pollution and restore the environment. As I am sure you know, activities that are concerned with problems of pollution are diffused through many, many of the agencies of Government and are really closely related to their missions.

For example, the Department of Health, Education, and Welfare has serious concerns about the problem of pollution in human health. The Department of Agriculture is very seriously concerned, and so forth. The Atomic Energy Commission is concerned, Interior is concerned. And I believe that each of those agencies must continue its concern and increase it in the future. There is a real problem in coordination. We have attempted to do this in a number of ways. One is through the preparation of reports on the broad problems, in which one gets together with the representatives of the numerous outside agencies—consultants—for a long period of time. During the course of this process there is a good deal of education and coordination that goes on simply because of the process itself.

We have also been concerned about the followup to what has been developed in the course of these studies, and have attempted to do this as best we could. For example, in the case of the most recent and most extensive of our reports on pollution problems, "Restoring the Quality of Our Environment," we have obtained from all of the agencies a summary of the actions that they feel they should take, and of the places where they feel that there is maybe overlap or where there isn't enough effort. We are in the process now of analyzing this and will work with the individual agency, and where necessary with more than one agency, to follow along on these questions.

Mr. DADDARIO. Do you mean that even though you are satisfied that the agencies are working with this problem, we must be careful and see to it that there is better coordination between them?

Dr. MACLEOD. I believe very strongly that in the future we must bring the competences of the individual agencies together on these problems, because in practically none of them as I see it is the competence of a single agency capable of handling the problem. Unless we do get the various agencies coming together for their solution, I don't think we will accomplish a solution within a reasonable period of time.

Mr. DADDARIO. Dr. MacLeod, as we have been holding these hearings we have been told constantly that we ought not to hold off doing things both because there is available technology which can solve some of our problems and also because we ought not to wait for a perfect solution. But I would like your opinion as to what we ought to be doing about these great expenditures which are presently before us. We have been told it will cost $25 to $30 billion to separate sanitary and storm sewers. We also are told we ought not to make these expenditures until we do some research which will cut down the cost as well as reducing the cost of the estimated one-half billion dollars per year required to purchase automobile exhaust devices for about 10 million cars a year. Are we paying proper attention to the area of research? Are we making the effort that needs to be made in these areas? We must remember that if we don't, we may make expenditures that do not result in the problem being solved.

Dr. MACLEOD. Mr. Daddario, in the case of the first example you used, of the combined sewers, there has been strong advocacy of very large expenditures for the separation of the storm and sanitary sewers. That figure which you gave, $20 to $25 billion, is commonly quoted, and I have no doubt, if one had to dig up all our cities and separate the sewers, that this figure is not too large. One must pause, however, in proceeding forthwith to try to find this amount of money; because as it turns out in the storm runoff in cities such as New York there is an enormous amount of organic material—wastes of one kind or another which one doesn't want to see dumped into the harbor any more than you want to see the sewers dumped directly into the harbor or into the Long Island Sound.

I don't think that this is as simple a problem—and I wish I were more of an expert on it—as merely separating the sewers. I think it has been emphasized by some of the people who have studied it that there is once again a systems approach that one has to take to this. One has to try through multiple means to prevent these, shall I call them, catastrophic runoffs that occur at times of great rain storms. If the water could be stored on rooftops, for example, and I'm not sure if this is practical, or if runoff could be minimized, then one might be able to divert this water more slowly into the regular sewage systems. But this has to be thoroughly studied from a systems point of view, and to my knowledge it has not been.

My information could be deficient on this, but 2 years ago when we were looking at the problem with the pollution panel, while it was apparent that a systems approach was needed, it wasn't apparent that it had been done then. As for the auto exhausts, Mr. Chairman, I quoted from one of our consultants, perhaps before you came in, regarding the situation as it may obtain in the Los Angeles area where new standards for exhaust emission have already been put into effect—that is, in the whole State of California. The estimate is that even though one can reduce the amount of effluent to the level stated in the standards, the increase in automotive traffic, in the burning of hydrocarbon fuels, is such that in about 15 years we will be just about back to where we are now.

In other words, unless there are very radical developments in the complete combustion of the hydrocarbon fuels that are used in auto-

mobiles, we are going to ameliorate the problem for some time but inevitably it will grow up again. This is unless alternative means of automotive propulsion that are reasonably efficient can be developed. The usual examples are to improve storage batteries and also to develop fuel cells so that they are lighter in weight and more economical. Either one of these would accomplish that. My understanding is that at the present time, with present technology, one couldn't introduce these other methods of propulsion; and probably, unless there is a good deal of public acceptance of the need, based on pollution and based on the eventual exhaustion of our resources of fossil fuels—unless the public becomes thoroughly aware of this—it will be very difficult indeed to introduce these even though they are much better technologically than they are now.

Mr. DADDARIO. This seems to be an area where we are making expenditures which are causing some gain in the fight against pollution. If you, yourself, were in a position to choose between spending half of a billion dollars on a device to cut down pollution from automobile exhaust and using the money for some other antipollution program, would you spend it on the device?

Dr. MACLEOD. I think we have two kinds of problems here. One is the short-range problem. I think we have seen in enough modern cities over the last few years an increase in noxious hydrocarbon products in the atmosphere so that we realize, I think naturally, that we must do something about them over the short range. I think over the short range, since the automobile is the greatest producer of these pollutants, that we have got to try to do something about the automobile reasonably promptly.

Over the longer range we must develop, I believe, alternative methods of propulsion. This is going to require a good deal of research and perhaps more development money, which is where the largest cost is as I'm sure you know in the introduction of anything new in the commercial world. So I think we have two problems. One, to abate over the short range, and two, to develop alternative methods to prevent in the longer range picture.

Mr. BROWN. Mr. Chairman, would you yield at that point?

Mr. DADDARIO. Yes, Mr. Brown.

Mr. BROWN. I'm interested in this discussion because in Los Angeles at least 15 years ago there was a lot of pressure for the development of some sort of smog control device for automobiles. Ten years ago the pressures were great enough to ask the automobile industry to engage in the research necessary to develop this. The State agencies have not engaged in any research whatsoever with regard to smog control devices in California. They have attempted to set standards, but the law in California is that the standards cannot become applicable until the industry develops two alternative devices. It just wasn't done. This is something which in my mind should be relatively simple technically, at least it is simple compared with developing a new form of propulsive power such as the fuel cell or battery-powered automobile. In 15 years the industry failed to devote sufficient funds to this relatively simple problem because it was insufficiently motivated. The question that I have is, do you think there is any likelihood that industry, because of the major changes it would mean in its whole method of opera-

tion, perhaps its merchandising philosophy, is likely in, say, the next 50 years, to devote enough of its own research funds to come up with an alternative type of propulsion to the internal combustion engine?

Dr. MACLEOD. That would be very much of a personal opinion and I suppose from that point of view it is no better than that of anyone else, and perhaps not as good as many others. I believe that if we do bring to the attention of the people at large the magnitude of the problem and the kinds of solutions that are necessary and if we do set standards which will require new technology in order to market, that one can have a profound effect on the kinds of instruments that are developed.

In the case of the battery powered vehicle or the fuel cell powered vehicle, I don't believe that up until this time the public has been so convinced that this will be significantly better than the improved autos with less amount of effluent from the exhaust, that the public is really convinced that we need to push for it. I know that some of the battery companies are working on improved batteries and certain of the large electric companies are working on fuel cells. I don't know really whether they could be working harder and that they could bring the day closer. I just don't know whether the magnitude of effort could be increased to accomplish this.

Mr. BROWN. The point that I'm making, is that in California where this exhaust effluent problem is the most serious, the public was well aware and eager for action 20 years ago and still no action was taken. When we decided that we needed fuel cells for the lunar program, the public didn't care whether we used fuel cells or not, but the needs of the project and the compulsion of the program resulted in their development. What I'm leading to is, Is it not possible that we are going to make rapid advances in this field only if the Federal Government takes a considerable amount of leadership in encouraging the necessary research and not rely on either the public or the industry?

Dr. MACLEOD. Yes, I believe, sir, the Federal Government must take leadership. I don't know how much in the way of resources the Federal Government needs to put into, for example, these two developments that we have been talking about, but I think this should be looked at, definitely.

Mr. DADDARIO. Dr. MacLeod, I hope we might have the opportunity to send some further questions to you. We have other witnesses today, but we hope you might provide us answers for the record. (Additional questions and answers for the record may be found in volume II.)

Dr. MACLEOD. I shall be very glad to.

Mr. DADDARIO. We certainly appreciate your being here.

(The complete prepared statement of Dr. Colin M. MacLeod follows:)

PREPARED STATEMENT OF DR. COLIN M. MACLEOD, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY

Mr. Chairman and members of the committee, although knowledge of the damaging effects of pollution has existed for a long time, particularly in idustrialized societies, the impulse to do something about it has been slow in coming. While there are multiple reasons why this has been so, perhaps the most important have been first, the slow appreciation by the public that human sewage

contains a variety of disease-producing microbes. Secondly, there has been a deep feeling, stemming from our frontier history, that the resources of this Continent are well-nigh inexhaustible, including the resources of water, air and land in which to dump our waste products. Finally, there is the strongly-held opinion that nature quickly purifies the man-contaminated environment, be it air, water or soil. While the last is true to a degree, we have overestimated badly the capacity of natural forces to restore the environment's quality, whether the contaminant be human sewage, industrial wastes, automotive effluents, pesticides or animal dejecta.

An increasing standard of living generates an increasing burden of wastes, so that the most affluent society has the capacity to produce the widest variety of pollutants in the largest amount.

Surely it should be a measure of the quality of our civilization that while we improve living standards through increased per capita income and other resources, at the same time we see to it that we don't foul our own nest, or if we have fouled it that we devote sufficient resources to clean it up and prevent further damage caused by our indifference and greed.

During the past few years, attitudes have been changing. The magnitude of the problem is now more generally appreciated by the public, the Congress and the Executive Branch, and a number of very important steps have been taken. Despite this favorable change in attitude, I question most seriously whether problems of pollution have been given the high priority they deserve; I question whether we are yet in the frame of mind to commit to their abatement the very large resources of brains and dollars that are going to be necessary in order to push back the flood, and to restore our natural habitat to something approaching its pristine state of great natural beauty.

As I have indicated, at the present time much of our populace is aware of some of our Nation's pollution problems. A few classical examples, such as the pollution of Lake Erie and the smog and pesticide problems, have been popular subjects for lay writers. Likewise, many persons in our population have been subjected to discomfort, losses, or disgusting sights and odors caused by pollution. Many of us have observed a once sparkling, clear trout stream that is now devoid of fish, with its waters odoriferous and green with noxious algae, or we have become aware that birds or other kinds of animal life which were once common to an area are now rare or gone. It is these kinds of obvious degradations and catastrophic changes which have finally awakened the public. Now the protests against pollution no longer come from a few in our population. At all levels in our society, concern is being increasingly expressed about the deterioration of our environment and there has arisen a determination to do something about it. The concern I expressed above is whether this determination is strong enough.

Although they appreciate a few facets of the problem, few people are aware of its scope and seriousness or of what is required to abate the tide of pollution. Likewise, few of us are aware of the multitude of changes and effects upon other forms of life and upon ecological processes which have accompanied each of the changes that we have viewed. In fact, scientific knowledge is sparse in this area—and badly needed.

It should be remembered that ecological change is not a new happening in the history of the earth and its inhabitants. The earth's surface has been undergoing physical changes for eons of time. The results have included the very formation of our atmosphere through biological action, topographic alterations such as the formation of mountain ranges, the origin and death of lakes and rivers, the rising of land masses from beneath the sea, and sometimes the sinking of terrestrial environments. Except for catastrophic events, such as are associated with volcanic activity and earthquakes, major modifications of the earth's crust have occurred slowly.

There have been also been gradual but extensive changes in the properties of the air, waters, and land. The quantitative chemical composition and temperature of the air and surface waters have changed. The oceans and certain lakes have increased in salinity. Soils have been formed and deposited in some areas and removed from other areas by water and wind erosions. Levels of nuclear radiation from natural sources have decreased with time, due to radioactive decay of radioactive minerals in the earth's surfce and because of changes in the atmosphere.

The biota of the earth has also gradually changed with time due to such evolutionary processes as biological adaption to environmental changes by genetic alterations and natural selection.

Wonderful as the genetic mechanisms are for ensuring diversity and adaptability to changes in our physical environment, it is important to remember that their response is relatively slow, especially for the highly organized forms of life. Evolutionary changes are geared to long spans of time—thousands and even millions of years.

Although species of organisms may become adapted to living under different environmental conditions by evolutionary processes which are entirely beyond their control and which occur only over very long periods of time, man has acquired the ability to intentionally and grossly change the environment to meet his desires. One of civilized man's chief goals has been to alter his environment to make his way of life easier and more secure, and to satisfy his ambitions to acquire possessions and prestige.

Not only has man changed his own environment but he has changed or is changing the physical environment for essentially all other creatures that live on earth. Since life evolved on earth, there has never been a biological influence that has so altered the environment. The stresses and changes that man has caused to the natural communities on earth compare in magnitude to those caused by the ice ages—and the long-term effects can be expected to be more severe unless man acts promptly to find and correct his errors. Biological alterations have never before occurred so rapidly and the speed of changes resulting from man's activities is accelerating.

The tremendous quantities of man's wastes which are poured into fresh waters, into the air, onto the land, and into the oceans constitutes one of the dominant abuses imposed on nature by man.

Marked changes have taken place in many of our streams, lakes, estuaries, and coastal waters because of their misuse. Many streams throughout the Eastern United States which once flourished with fish are now barren due to pollution from industrial and domestic sources. Valuable commercial species of fish, such as salmon and shad, have disappeared from great rivers. There are many serious problems from overenrichment of slow-flowing and impounded inland waters and estuaries from domestic and agricultural wastes. Large areas of oyster beds which were an important source of food in former times and which once represented an important part of our commercial oyster fishery have either been contaminated by infectious microbes from sewage during recent years or conditions for growth have been so degraded that productivity is much less than it used to be.

Well-known examples of lakes that have become seriously degraded by pollution include Lakes Washington, Tahoe, and Erie; the Potomac is a classical example among rivers; the tidal waters of the Sacramento River are an example of a polluted estuary; and a good example of a degraded marine environment is the coastal waters of Long Island.

Domestic wastes, the excrement from farm animals, surface runoff from some agricultural lands, and certain industrial wastes contain materials which are nutrients for plants. When such materials are discharged into surface waters, they stimulate the growth of aquatic plants. Overenrichment may cause unsightly algae blooms to develop and the oxygen content of the water may become depleted until many or all forms of aquatic animal life perish. In addition to loss of fishery resources, overenrichment limits or destroys recreational values of an area, and in the case of lakes it causes premature and speeded aging.

As yet we do not have sufficient information to develop methods for controlling over-fertilization of our waters, simply because we have not done enough research and development on the subject. We do not know whether it will be possible or feasible to reverse or to stop advanced cases of eutrophication or over-fertilization in lakes. The problem is complex and likely will be very expensive to solve. It will require new techniques for treating sewage because our current methods are designed primarily for the removal or destruction of disease-producing microorganisms. By present methods, primary treatment removes the large particulates. In secondary treatment, microbiological processes break down complex organic materials to simple, soluble compounds which form a rich nutrient brew that flows into the natural water systems where it nurtures the mass growth of noxious plants. It is clear that tertiary sewage

treatment systems must be developed and adopted widely for the removal of the soluble nutrients if we are to preserve some of our most precious natural resources of water.

Air pollutants include many potentially hazardous materials such as wastes from the combustion of fossil fuels, pesticides, radioactive materials from nuclear detonation, and various industrial effluents.

Irritation of the eyes and respiratory tract from polluted air has been common for many years in Los Angeles because of the geographic and climatic pecularities of that area. Los Angeles no longer is unique in this respect. Many other American cities, including New York and even non-industrial Washington, D.C., have experienced episodes in which the atmospheric concentration of automotive effluents reached irritating levels—and this will get worse before it gets better because every day there are more automobiles, burning more gasoline which crowd into the centers of our cities.

Up to the present time, except for a very few catastrophic episodes, there is little proof that the levels of air pollutants which accumulate in the air over our cities adversely affect the health of normal people, even though the pollutants may cause irritation. This does not mean that there are no detrimental effects on health, but only that by our present methods we are unable to detect or assess the effects of low levels of toxic compounds over long periods of time. In making these assessments it will be necessary to conduct detailed epidemiological studies on the young and healthy segment of the population but, probably more significantly, on the aged and infirm and those who suffer from cardiac or pulmonary ailments. Because of our judgment that smog may be harmful to human health and to the quality of living for city dwellers, we have embarked upon a program to reduce the concentration of pollutants from automotive exhausts. This is only "stop gap" action, however. Much research and development, and probably some major changes in transportation, will be required to ultimately control the problem.

One of the most intriguing and potentially significant changes that is taking place in our environment is the buildup of carbon dioxide in the atmosphere from the tremendous consumption of fossil fuels. At the present and projected rates of coal, oil, and natural gas consumption, there is good reason to believe that the carbon dioxide level in the earth's atmosphere will increase to an extent which could cause a significant rise in the air temperature of the earth by the time year 2000 is reached. If this occurs, the communities of natural vegetation can be expected to change, which would effect changes of corresponding magnitude in the natural populations of terrestrial animals. Glaciers would melt and ultimately even the temperature of the oceans would rise. Melting of the ice caps would cause rising of the ocean levels, or if the increase resulted in increased rates of precipitation in the polar regions, the ice caps might grow.

At this time, we can only theorize what might happen if the carbon dioxide content of the atmosphere continues to increase. Our understanding is insufficient to predict with confidence what will happen to the plants and animals and to the rest of our physical environment.

Pollution of our soils originates from many sources but at the present time the most important are related mainly to agricultural practices. The pollutants include such materials as pesticides, increased alkalinity or salinity due to irrigation practices, and in some areas wastes from domestic animals.

Solid wastes, including discarded packaging and junk automobiles, which so obviously degrade our landscape, constitute another aspect of our pollution problem which is in dire need of action. Of equal importance to the unsightliness of such materials is the waste and loss of the materials that they contain as well as the distressing propensity to destroy valuable natural resources such as marshes by dumping this junk into them.

Under natural conditions many species tend to live together in communities. This complex of species and the interrelationships that they share functions to maintain a stability which is commonly referred to as a "balance of nature." These ecological systems have been developed by the slow process of evolution, by each species finding its niche in a particular environment. As the environment becomes more harsh, the diversity of species decreases.

Many of the activities of man have resulted in the reduction of species. As the concentration of pollutants in a particular natural environment increases, the number of species decreases until finally all life there may be destroyed.

Another interesting correlation may be found in the results of intentional alterations of the bioenvironment to meet increased immediate needs for human

food. Farms have become more specialized in the types of products that they produce and the sizes of areas devoted to single types of crops have consistently increased. This tends to reduce natural stability and man must become increasingly diligent to protect his crops from catastrophies such as infestations by plant pathogens or by population bursts of injurious insects. This necessity has supported rapid advancement in production and usage of various kinds of pesticides. These materials are used not only on most of our cultivated crops but also on large areas of forests and grazing lands. They are also used to control insects which spread human diseases and to control pests in our houses and yards and pests of our domestic animals.

In the early days of insect control, persistence of the insecticide was considered an important virtue because the residual activity provided control over an extended period of time. This characteristic is undesirable under many conditions because the persistent toxin can cause death or damage to desirable species even though they may be at great distances from where the pesticide was applied. The classical examples are so well known that I do not need to refer you to them. It is of great significance that during the past 3 or 4 years there has been a large shift toward pesticides that are more readily degradable and a market shift in emphasis by Federal agencies, particularly USDA, toward other methods of pest control. A considerable increase in effort, however, is desirable.

I have indicated a few of the pollution problems which need more research and some where we can apply what we know already. Actually, we do not have adequate understanding of many of the basic processes of the bioenvironment; we do not adequately understand the interrelationships between various species of plants and animals, and we have very little knowledge of the effects of environmental stresses upon natural populations and communities of organisms. We are particularly deficient in our knowledge of the chronic effects on man, plant and animal species, and ecological systems from long-term exposures to low levels of pollutants and other environmental stresses. This basic information is essential to enable us to assess the biological hazards of pollutants, to enable us to establish more meaningful tolerance levels of pollutants, and to assist in the improvement of methods of pollution control.

To achieve the needed advancements of scientific knowledge and technology, it will be necessary to attract many more highly qualified scientists and engineers to the many aspects of the broad problem. It is of particular importance to devote adequate attention to the advancement of basic knowledge.

These requirements indicate the need for increased Federal support of training and research through the various responsible agencies. Continued effort should be devoted to improve intramural research and development programs but at the same time more effort should be directed to utilizing the much greater pool of talent outside Government by increasing sound research, grant and contract programs with universities, non-profit research organizations and industry.

As a nation we have no really long-term plans to deal with either the problems associated with the carbon dioxide buildup in the atmosphere or the eventual exhaustion of our valuable fossil fuel supplies. Concerning the supplies of fossil fuel, there is no answer for the long term except for the development of new sources of energy such as nuclear power or solar or tidal energy. Nuclear power carries its burden of environmental hazards, but in the light of what we now know, the hazards from controlled nuclear energy may be less troublesome to manage than the use of fossil fuels with their attended buildup of atmospheric carbon dioxide.

It is time that our nation begins to work diligently toward the goal of efficiently recycling materials and utilizing natural energies for our power requirements. A concentrated effort devoted to developing methods and policies to effect the recycling of used materials back into the production of new products would result in both conserving our wealth of natural resources and materials which we must import, and it would contribute greatly to the alleviation of pollution. Our disappearing fossil fuels could perhaps serve their highest use as raw materials rather than being lost forever by burning them as sources of power. Our present usage of fossil fuels is much more serious than the exploitation of the forests by our ancestors because the supply that we are depleting does not represent the crop of one year or one century but the crop of many hundreds of thousands, indeed millions, of years. The loss cannot be redeemed by any of the powers of man.

Increasingly power requirements must be met by efficient usage of nuclear energy, and other sources should be utilized such as solar energy, the tides, and perhaps the heat of the earth's core.

Since it was established in 1962, the Office of Science and Technology has been actively concerned with pollution problems. The President's Science Advisory Committee Report, *Use of Pesticides*, was published in 1963 and since then the Office has assisted in the development and in the activities of the Federal Committee on Pest Control. The Federal Council for Science and Technology's Committee on Water Resources Research has devoted considerable attention to water pollution. The recent PSAC Report, *Effective Use of the Sea*, includes attention to marine pollution problems. The recent Report of PSAC, *Restoring the Quality of Our Environment*, which was published last winter is devoted broadly and extensively to the subject of pollution. It includes numerous specific recommendations that pertain to control. An assessment of the various agencies' responses to that Report has just been completed and plans are actively afoot for further implementation including coordination of activities by Federal agencies.

The pollution problem is closely related to our national concern for preservation of natural beauty. The Office of Science and Technology and the Bureau of the Budget are now completing a study of how the Federal Government can best help to advance our understanding of natural plant and animal communities and their interactions with man. The results of this study will contribute information and recommendations which should be useful to support and advance programs needed for pollution control.

In the future the Office of Science and Technology will continue to provide leadership and to conduct evaluations and coordinating actions among the Federal agencies to develop policies and programs which will improve the control of pollution on land, in the air, and in the water; which will advance the restoration of degraded environments, and protect important natural systems which have not yet been spoiled by man.

Mr. DADDARIO. Our next witness is Dr. John L. Buckley, Assistant to the Science Adviser of the Department of the Interior.

Dr. Buckley, good morning. We are happy to have you here and I think we will go right into your statement.

STATEMENT OF DR. JOHN L. BUCKLEY, OFFICE OF ECOLOGICAL RESEARCH COORDINATOR, THE SCIENCE ADVISER, U.S. DEPARTMENT OF THE INTERIOR

Dr. BUCKLEY. In the interest of time, Mr. Chairman, I will dispense with most of what I have provided in the written statement. I assume my prepared statement will be printed in the record. I know that your committee does its homework. I'm sure that many of you have already looked at what I intended to say. It seems to me that the lines of questioning that have been pursued this morning are particularly fruitful ones and I welcome a chance to discuss some of these matters with you.

The tenor of the questioning and also my statement is that we live in a world which we are able to modify and in fact have modified to a very considerable extent. We have certain choices in modification. In at least limited environments, such as in a spaceship, we are able to provide the needs of life at least for a relatively short span of time. I suppose it is conceivable that we might be able to manage the earth as a whole in somewhat near this fashion. I'm not sure that I would care to live here if we were to do this, but that may be nothing other than a matter of personal choice. At the other extreme there are those of us who would prefer to see things as untouched as possible,

and yet that is clearly not the way in which we are going to live in the future. So we are really faced with a problem of understanding enough about our environment, its physical side and its biological side, so that we can most efficiently use the resources that are available to us.

Philosophically it seems to me that we have considered all of these resources as essentially "free" in the past and there were no constraints against the dumping of waste—and by wastes I mean those things that are not useful to us at a particular point in time or in a particular concentration or in a particular place or in a particular form—wherever was most convenient. With certain very toxic materials, we now have changed this philosophy so that it is very much the other way around. In the handling of pesticides, for example, the responsibility rests with industry or the proponent of a particular use, to demonstrate that the use will be both advantageous for the purpose for which it is intended and equally that it will not be disadvantageous to other uses of resources. We have not yet expanded this philosophy to many other pollutants. The nuclear energy business is one other example. Here there were all sorts of possibilities of escapes of materials into the environment and we could foresee enough difficulty that we exercised, relatively speaking, extreme care in the way we handled it. The result has been that we have learned to handle nuclear energy so as to achieve maximum benefits with a minimum of disadvantages.

One of the issues raised by your Research Management Advisory Panel relates to the appropriateness of considering direct effects on people as the principal measure of pollution. I submit that it is inappropriate. I think quite clearly that man is the center of the universe and all our activities are oriented around him. But it isn't just the physical needs—the need for food and oxygen and water and these sorts of things we must be concerned with. Rather it is all of the things that man needs, directly and indirectly. It is conceivable that we might be able eventually to take the separate elements that occur in the universe and combine them into substances which we can use for human food by some means other than using green plants as the basic mechanism. At the present time, however, we totally depend upon green plants for serving this need. The first thing they do is capture energy from the sun and convert this into plant materials. In the process, they release oxygen, take up carbon dioxide from the atmosphere, take up minerals from the soil and so on. These plants in turn are fed on by other living organisms, or if they die without having been eaten by an animal of some sort, then some of the microorganisms in turn break them down into smaller pieces and eventually the nutrients are put back into the cycle.

It seems to me that we depend on these services and we best be sure that those things we do to the environment do not seriously disrupt these functions.

There are some other things living organisms do that concern me. From our point of view they are sort of inadvertent things that we would really prefer that they not do. In the process of cycling both energy and nutrients they also are able to, and in fact do, pick up some of the heavy metals, some of the relatively persistent and resistant organic compounds and pass these on—in some cases with no changes and in some cases with extensive changes through metabolic

processes—so that when one organism feeds on another it in turn tends to accumulate these.

What I am really saying is that it seems to me we are going to live in the world that we have now. One of the things that we need to do in managing this world is to get rid of wastes that are disadvantageous to us. But in the process of doing so we need to make sure that, while we utilize fully the capacity of the environment to assimilate them, we do not overburden this capacity to the point that we seriously upset the way in which the system functions. You can take this and twist it the other way around and make an emotional pitch that we don't want to see things changed or we must conserve this or that. But basic to this is a biological need on the part of man that won't be met if we disrupt these processes too extremely. So, I would lead them to the point that it seems to me, I don't really wish to talk about the adequacy of technology. I wish to talk about our lack of basic understanding of the processes that take place in these systems and even such obvious things as present distribution patterns of living organisms, of abundances of them in different places, the rates at which they are capable of adapting as individuals, the rates at which they are able to genetically change with time. All these understandings are necessary as a solid base on which we can decide how much of what material we can put at what part of the environment. I think without belaboring the point further, sir, I would rather respond to questions.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. I have no questions now.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. Do you have any comments about some of the questions which we asked earlier? Would you be in disagreement with any of the general statements that the earlier witness made in response to questions? We have gone over thoroughly the ground that you are primarily interested in.

Dr. BUCKLEY. No, I think for the most part I agree with the comments that my friend, Dr. MacLeod, has made. He and I very seldom have any violent disagreements.

Mr. CONABLE. Are you satisfied with the coordination that is going on in this area within the Federal Government itself?

Dr. BUCKLEY. Well, if we are talking about the field that I have specifically addressed myself to, I'm not especially concerned about the problem of coordination. I'm concerned about the problem of quantity of work that is going on which I think is grossly inadequate to meeting these needs. Secondly, I would point out that the agencies that are now for the most part concerned with this subject have a rather special concern. Within the Department of the Interior, for example, in our water pollution control agency we have a concern with these kinds of problems but only if they are in the vicinity of water. If we consider the Fish and Wildlife Service, they too have a concern. It is not limited geographically, but the concern is centered around economically valuable forms of fish and wildlife and those things that influence them. Or if we take the Public Health Service, their concern is with these same kinds of problems but only as they directly affect man. We do have a segmentation this way.

Mr. CONABLE. Apparently you are concerned about the quantity of research going on that is directed toward the general problem of

research—understanding what is involved in these various physical processes and understanding more about our environment itself rather than any specific research problems.

Dr. BUCKLEY. Yes, I think this is generally so. I would say that there are some opportunities for synthesis of knowledge now available that have up until now been overlooked.

I think we have, for example, information on distributions, changes and things of this sort hidden away in minds of men that ought to be extracted and put to use. One of our problems in talking about pollution always is that we sort of imply that pollution is in fact disadvantageous change. Then you are faced with the problem, change compared to what? And even in such an important area to us as San Francisco Bay, if you want to go back and look at what San Francisco Bay was like chemically, biologically 10 or 20 years ago, quantitative evidence is very scarce. You end up with the recollections of a fisherman who remembers that he used to catch x number of fish and now he catches x minus number of fish. But you don't know whether he really caught that number of fish before or whether he forgot the days when the fishing wasn't so good—you don't know whether distance in time has dulled his recollection. There are very real problems here, it seems to me, in just this matter of assessing change.

The next point that I should comment on is the statement by the Research Management Advisory Panel that change of an abnormal nature in animal populations may be considered as a sort of warning of things that may happen to man. Again, I would raise the question of what constitutes "normal" and, therefore, what is "abnormal." For most wild population we don't really have any good idea how great the change may usually be without the pressures of man—from one place to another, from one year to another. We do know that such changes are very considerable in some cases.

The third point related to this is that these animals don't live by "averages," yet the numbers one often ends up with are monthly averages of dissolved oxygen for example. It doesn't do a fish much good to have dissolved oxygen that is totally adequate for 30 days in a 31-day month, and have essentially no oxygen on the 31st day. The average figure will provide you with information about changes in time, or permit comparisons of one place with another but it won't help the organism a great deal.

Mr. DADDARIO. How do we get this information? We aren't getting it now since there is no way of distinguishing the normal from the abnormal.

Senator Nelson has introduced a bill which would establish a Department of Ecology. Do you think we ought to centralize in this way or how do you suggest we go about it?

Dr. BUCKLEY. Well, you put me in somewhat of a spot, sir. Senator Nelson's bill has not been either favorably reported upon or unfavorably reported upon.

Mr. DADDARIO. I understand and I bring it up not because I support it or don't support it, but rather because you raise this question in such an interesting way. You remind this committee that we need certainly to know more about this area where you say a great deal of work needs to be done.

Dr. BUCKLEY. Yes, I think some additional work is necessary whether it is a result of Senator Nelson's bill or something along this line, and without discussing whether it ought to be in the Department of the Interior or some other place. Clearly, I think it ought to be in the Department of the Interior or I wouldn't have returned to that Department to attempt to strengthen its work in ecology. So, laying my biases out in front of you, yes, I think this kind of thing is necessary on a rather vastly expanded scale.

On the other hand, when we are talking about money for this sort of thing, it need not be the kind of money we are talking about in space programs. We really are starting from a different base and some of the basic ecology that seems to be necessary and some of the survey information is something that would represent, I suppose, an investment of a few tens of millions of dollars rather than hundreds of millions of dollars or more on an annual basis. I sincerely believe that we need an assembly of the information that we now have—and I don't see the mechanism for doing this—a survey of what now is present and what is happening to it, and certainly an increase in basic research that tells us more about the basic processes that are at work in these environments.

Mr. DADDARIO. You said that our ability to detect change is not good because our experience has not been long. Harmful effects may well be occurring. Various life processes and cycles are in delicate balance so that if you upset one you may affect others, too. If we ignore this and if changes continue, it can have a disastrous effect throughout the whole life system.

Dr. BUCKLEY. Yes, I don't want to sound like a prophet of doom and I don't personally feel that this is that kind of problem.

On the other hand, I'm a strong believer in foresight rather than hindsight whenever it can be exercised.

Let's take the case of the oyster, not because the oyster is necessarily so important and not with any intent to influence its marketability or anything of this sort. The oyster processes a large quantity of water an hour. It takes in up to 40 liters of water in an hour so it is a remarkably effective filtering system. It has the capability of removing from the environment materials that are present in a very dilute way. There are some data which suggest that they have the ability of concentrating some pollutants by a factor of 70,000.

The question, it seems to me, that one needs to go to from that is—are there levels of these substances that are low enough in the environment that the oyster is not able to pick them up? And again I have very little information to offer on that.

I do know that if you go to levels of DDT of 1 in 10^{14}, that is one part of DDT in a hundred thousand billion, then the oyster in at least a period of 20 days acquires no detectable amount of DDT. I know that at about one part in a hundred billion, the oyster in 2 weeks will pick up quantities that you do detect. This is not to say that the oyster is damaged by that level. It is simply to say that he has the capacity to extract at that level.

Other organisms, including man, feed on oysters. It is conceivable that the oyster will store away quantities of these in sufficiently high concentration to be harmful to man if he eats them.

We have monitoring programs that are aimed at detecting the levels that are now present; we have regulations that prohibit shipment of these interstate if they have any substantial levels and so on.

But, again, one other point that this opens up, and that I might have commented on, is that a great deal of our work in pollution or in relation to pesticides has really been aimed at sort of stating how bad the situation is. It seems to me that this is the wrong point of view.

Rather, what we really need to know, because surely we are going to have some levels of pollutants in the environment, are what levels we can have without detriment to the environment. The research may be done in the same way, but the results will be much more useful to us, in fact, if they are phrased in such a way that they tell us that this is allowable and that it will have no effect insofar as we can judge now, rather than the other way around.

Mr. DADDARIO. So, you need to have a better idea of what you must accomplish.

Dr. BUCKLEY. Yes; it seems too much effort up until now has been in trying to demonstrate to people such as you and to the general public and me that there is really a valid problem that we ought to be concerned about.

Shucks, I'm convinced. What I want to know is, "What are we going to do about this problem?" We are going to have wastes of some sort or another, and we are going to have to segregate these into some part of the environment where they won't be disadvantageous to us. We need to have sufficient knowledge that we can do this without damage—so we can have our cake and eat it, too.

We may use the oceans to dispose of some of these wastes. In a natural world, they were sinks—almost everything eventually ran into the oceans. Today we tend to treat them as though they would do this for all sorts of artificial products as well as natural ones, and no doubt, with sufficient knowledge, we can afford to use them deliberately for this purpose. But even the oceans are not inexhaustible resources, and do not have a capacity to absorb unlimited quantities of wastes. And the difficulty is intensified because we usually place these waste materials in fairly localized areas, usually quite close to shore where they are subject to recycling.

This suggests to me that in the estuaries we may need to come around soon to a kind of landscaping zoning, a decision that for the estuaries the principle of multiple use won't work.

An estuary can be used either for this purpose or for something else. Carrying it to an extreme, clearly if one dredges and builds industrial sites, this is one valuable use for an estuary. At the same time, you can't expect the shallow waters along the edge of it to serve as a nursery ground for shrimp and other aquatic resources.

This is a choice that you have to make and it seems to me that a zoning concept is the way to make it.

Can we afford to fill or pollute all of them since they are so very important to us in terms of marine products? I don't think we can. At the moment, there isn't any way of saying that you can't do it to this estuary but it is all right to do it to that one.

Mr. DADDARIO. Do we have enough ecologists available to make a solid beginning in this area? If we don't, how do we get them?

Dr. BUCKLEY. Well, let me comment for just a moment on that. I'm not sure what an ecologist is, but it doesn't seem to me that one sets out necessarily to train an ecologist. It seems more than anything else that ecology is a point of view, a recognition of the interactions that take place, so it doesn't mean to me that you have to have a man who goes through a set period of training and at the end of this comes out an ecologist. He may do this and there are a dozen or so institutions around the country that do offer graduate training and do produce people with these capabilities and many of them are first-rate people. But there are many other first-rate ecologists who were trained as fishery people or foresters or almost any kind of field biologist. I think for my purpose, I would restrict this to the biological field rather than others, but this is not necessarily so because I can think of some people who are trained in physical science who are also first-rate ecologists.

How do we get them? It seems to me that we get them as we need them. In the first place, this hasn't been an attractive field to go into. It has been been attractive intellectually, but the employment possibilities have been, if not nil, not very striking, and while I might say that money alone will not cure this sort of thing, it seems to me that at least a sufficient amount of money in the sense of available jobs and so on is one of the requirements without which this will not happen. I think that it is sort of a chicken-and-egg thing.

I am not suggesting that a large amount of money would suddenly produce ecologists, but I am saying that without a relatively large amount of money we are not likely to be able to stimulate an additional number of people into the field.

Mr. DADDARIO. Is ecology sufficiently attractive intellectually so that, if there were programs which had direction, purpose, and force behind them, people would be attracted to it?

Dr. BUCKLEY. Yes, I would say so—both in terms of an intellectual challenge and problems which are subject to actual solution.

Beyond this, I think solution of such problems have a social importance, and most scientists will ultimately admit that, in addition to basic curiosity, they are interested in the well-being and contributing to the well-being of the world.

Mr. BROWN. Mr. Chairman.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Might I suggest that we could solve the problem of providing additional funding and carrier opportunities if we retitled these ecologists as biological systems engineers and let the DOD finance them.

Dr. BUCKLEY. May I make only one disparaging comment on systems analysis, but it seems to me this is sort of an organized commonsense in the way that I like to think of it in regard to environment. It has some very sophisticated practitioners and some requirements for highly skilled methodology. Basically it really lets us apply commonsense in the best possible manner to the solution of a particular problem and lets us eliminate many of the constraints that traditional thinking imposes.

I'm not saying systems analysis is not a highly worthwhile thing. I firmly believe that it is. Just as I feel that computer modeling in

regard to problems is particularly useful in my field to enable us to point out what we need to know.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. I'm tempted to begin with a defense of the concept of systems engineering. It is true that it is often called organized commonsense and it is meant to be, but it is marked in the modern world by the use of mathematical models which are the key.

Ecologists have been using this tool for a good many years. I remember that on the first occasion I had to use an electronic computer I discovered that the problem I was trying to solve had already been solved by an ecologist who was working on the population problem. Ecologists have, in a sense, been systems engineers for a long time.

Secondly, I notice that you are willing to use computers to solve problems and to propose possible solutions, so I feel that for one group to run down another is a little bit inappropriate. They are doing different things with the same tool.

I would like to ask a serious question now. Do we have a biodegradable DDT yet or don't we?

Dr. BUCKLEY. It is by some organisms and not by others and it is a matter of degree. You and I take in DDT and transform this into a variety of compounds gradually removing the chlorines from it. We store a certain amount of it in our fat without change. Some other parts, we eliminate primarily through the urine.

We just gradually break this down. In that sense, it is degradable. It is not like some of the materials which are totally nondegradable.

Biodegradability in relation to pesticides seems to me to offer some very real problems. First of all, some of these need a certain length of time in residence in order to accomplish a certain end. I don't know where you would draw the line on degradability.

Mr. VIVIAN. I think you will agree that the DDT we have been using remains active far beyond its intended valuable life.

Dr. BUCKLEY. I think there is no question about this, and if one wishes to pursue DDT sort of to the end point here I can't think of specific uses of DDT that ought to be prohibited and in the long run if we come to a bona fide need to reduce the amount of DDT or prevent further buildups of it, then I think we are faced with overall decisions on it, not piecemeal decisions.

Mr. VIVIAN. I understand that. The question I am trying to get to is whether we are working fast enough and ambitiously enough on types of insecticides which might replace DDT and which would have a much more controlled lifetime. Is there enough work on that subject?

Dr. BUCKLEY. I don't think there is ever enough work, but I think there has been a very great increase in work by industry as well as in agencies of Government and I think the regulatory patterns have stimulated this very greatly. When I make these remarks, I restrict them largely to application within the United States, not to the world as a whole, though.

Mr. VIVIAN. Why should an individual farmer be concerned with using something other than DDT, particularly something that might cost more?

Dr. BUCKLEY. Why should he?

Mr. VIVIAN. Yes.

Dr. BUCKLEY. I don't think he should. As an individual.

Mr. VIVIAN. What, then, will cause the chemical industry to produce chemicals which the farmer probably won't buy?

Dr. BUCKLEY. The regulatory pattern that we use with insecticides and pesticides in general is that they must be approved by the Department of Agriculture on the basis of their effectiveness and, second, on the basis of lack of adverse effect within their approved use.

If there is a whole series of compounds available for a particular use, then we turn next to the recommending procedures. Again the Department of Agriculture has a fairly elaborate system through the State experiment stations, and so forth, for making recommendations. It seems to me that you have a whole series of pressures that urge the farmer to use the safest compound.

If at the same time, he is given a tool which is as effective as the one he formerly used, I think you have some hope in moving in this direction. I don't see this as an open and shut situation with the present regulatory systems.

Mr. VIVIAN. But we will all agree that there is too much DDT in the world's "circulatory" system.

Dr. BUCKLEY. We certainly know that it is very widespread.

What we really don't know is how much of a disadvantage it really is in those places where it is present.

Mr. VIVIAN. Is it increasing?

Dr. BUCKLEY. In the United States its use is decreasing.

In the world as a whole, its use is increasing.

Mr. VIVIAN. And there is evidence it will last for many, many years, is that right?

Dr. BUCKLEY. Yes.

Mr. VIVIAN. So even if we continue the same rate of usage, the total will undoubtedly increase throughout the world.

Dr. BUCKLEY. Yes; although if you take again the human being in the United States (this relates to that matter of change, again), if you go back to the early 1950's, I think the evidence is that there is no increase in the quantity of DDT and metabolates present in the human population of the United States.

The sample numbers are very small, but there is nothing there to suggest a very marked increase and in fact they suggest a leveling off.

Recent intake may have been somewhat lower than before. I'm not sure but what we have reached some static point with excretion balancing intake, and with this point hopefully below a point of biological damage.

Mr. VIVIAN. Have we developed anything that might be called a sweep-up chemical? In other words, if you have an excess of acid in a stream, you dump in some base to react with it and in some respect change the chemical structure. Do we have chemicals which can reduce the DDT present?

Dr. BUCKLEY. To my knowledge we do not. We did face a problem with benzenehexachloride a number of years ago when it was used on potato fields and it made potatoes taste musty. People did at that time try putting activated carbon on the fields and they were able to reduce uptake by potatoes.

Mr. VIVIAN. We have not developed any chemicals for minimizing or reducing the concentration?

Dr. BUCKLEY. No; although clearly we can do this in the laboratory by fairly extreme change in the chemical environment.

Mr. VIVIAN. Let me ask a question which I think is probably somewhat secondary. You indicate that oysters are effective in concentrating DDT. What happens if you raise oysters in a bed? Can you use these as a means of removing DDT from effluents or can't you?

Dr. BUCKLEY. This is one of those systems problems that we both would agree is important. I don't know the volume of flow that goes through this bed. I don't know the total amount of DDT in it. I don't know the effective amount that the individual oyster would extract from this.

Mr. VIVIAN. You talked about a problem in California where DDT concentration increased as it went from water to plankton to fish to a bird. Finally, the bird died from an overconcentration. Have you found any way of breaking that chain?

Mr. DADDARIO. That's what we are talking about, we have got to find out how to break that chain.

Dr. BUCKLEY. Gradually in the passing of time DDT is no longer present in the environment in sufficient quantity and there is a decreasing amount present in plankton and decreasing amount present in fish and the end result is that the problem is no longer present there. Of course, having this recognized problem, we did not add any more DDT to Clear Lake, Calif. We used other chemicals which were more degradable for the control of the gnat.

Mr. VIVIAN. How did you enforce use of the other chemicals?

Dr. BUCKLEY. In that particular case, it was a State-sponsored program for the control of the Clear Lake gnat and there were no problems. People knew there was a severe problem and one they felt they didn't want to have.

Mr. VIVIAN. In the discussion you have had with the chairman on the subject of how many ecologists there are and how many persons trained in related fields, you refer to the complexity of ecological problems.

It seems to me that the task of learning even a single specie is quite large. To learn the ecological background of the thousands and thousands of insects, birds, fish, is really an enormous task. Then to try to reduce this to some sort of solution—isn't this a task that is two or three orders of magnitude beyond the capabilities of the people in this field in the United States? Aren't we a long way from having any extensive knowledge, really?

Dr. BUCKLEY. Yes, we are. I wouldn't propose that we will in a short time have answers to these questions. It seems to me that we can do very much better than we now do with the available people and by a systemization of the knowledge that we now have.

Secondly, I don't think, at least I have high hopes that it isn't necessary to understand all about each species, but rather one can look at certain environments and hopefully understand the processes that take place in them.

Now, it may be different species that are present in each one, but they fill the same ecological role—they may transfer nutrients from

one level to another or they may break down organic matter, or they may perform some other biological function. A whole host of different organisms may be involved in different places, but it seems to me an understanding of the rates at which these processes take place and the pressures which there are and their effects on these processes are important to understand. I think these are much more likely susceptible to understanding than is a total understanding of the role and behavior of each of these separate species. I think one has to study the community of organisms rather than individuals.

Mr. VIVIAN. In reference to measurements of these characteristics, you mention the environment which is a subject certainly receiving attention these days. Are you actively monitoring pollution in various places in the United States? Specifically, is there any active on-line monitoring going on at the present?

Dr. BUCKLEY. Yes; the first that I know of was in the Ohio River Valley, the Ohio River Valley Sanitary Committee, and it also is done to a limited extent in quite a number of other places.

Mr. VIVIAN. What is done in the Ohio River Valley?

Dr. BUCKLEY. I am not sure of the number of stations and even the variables that are measured, but temperature and oxygen and light and a series of these things which in the aggregate tell you a large amount about the quality.

Mr. VIVIAN. Do you do this downstream from major polluters?

Dr. BUCKLEY. Yes, in some cases.

Mr. VIVIAN. Do you have any plan to monitor and relay back the information?

Dr. BUCKLEY. May I say I only report this to you as something which I don't do nor does the Department of the Interior on the Ohio River. This is a cooperative venture of some 14 States with some cooperation of the Federal Government. I think that the answer to that is probably "No" so far as individual sources, all individual sources. I think one can certainly do this in terms of stretches of the river in understanding what changes there are from place to place. I would point out that aside from that, there are some possibilities of using some of the satellites at least for temperature changes, things of this sort in the ocean, also the possible use of infrared sensors for picking up differences in photosynthesis which in turn is a measure of total energy output of a particular environment and you can do this in remote areas where you can't get at it in other ways. At a practical level yet, I think the answer is "No."

Mr. VIVIAN. Mr. Chairman, I have no further questions for Dr. Buckley. I wonder if Dr. MacLeod is here.

Mr. DADDARIO. He has left, but if you have some questions we can get them to him.

Dr. BUCKLEY. Mr. Chairman, may I point out that I felt a little regretful that Mr. Vivian hadn't had a chance to ask questions and I was sure if I made a comment about systems analysis Mr. Vivian would take the opportunity to ask questions, so I feel that I pulled your leg a little bit.

Mr. DADDARIO. Well, you certainly got him to rise. I have been interested in the dialog that has developed between you two and I hate to break up the rapport, but we must proceed to another witness.

May we send you some questions?

Dr. BUCKLEY. Yes.

(Additional questions and answers for the record may be found in vol. II.)

(The complete prepared statement of Dr. John L. Buckley follows:)

PREPARED STATEMENT OF DR. JOHN L. BUCKLEY, ECOLOGICAL RESEARCH COORDINATOR, OFFICE OF THE SCIENCE ADVISER, U.S. DEPARTMENT OF THE INTERIOR

Chairman Daddario, members of the subcommittee, I am delighted to have the opportunity to discuss with you the "adequacy of technology for pollution abatement." Your committee is certainly to be commended for its effort to stimulate creative thinking about environmental protection as a whole. The Research Management Advisory Panel report is itself a perceptive document that will stimulate creative thought in attempts to face up to the issues it raises.

We all recognize that pollution is a matter of serious concern, and I shall not dwell on how bad the situation is. Many of the witnesses who have appeared before you have discussed in detail needed hardware and instrumentation and integrated systems for effective control of pollution. I plan to confine my remarks largely to the inadequacies in basic knowledge rather than to technology and my personal interest is greatest in understanding the "risk" side of the benefit-risk equation.

Of course, I agree with the statement of the panel "* * * it appears obvious that the basic issue in the field of environmental pollution relates to the definition of goals. The definition must be specific enough to form a basis for policy formulation. Answers are needed to questions such as: How clean should this stream be? What limits should be placed on emissions into the atmosphere here? To what extent can this land assimiliate man-made wastes or other products?"

While we can probably all agree that as a general goal, we want an environment of a quality truly fit to live in and pass on with pride to future generations, we have not yet agreed on the environmental quality standards that we must specify to meet this goal. A suitable environment will fulfill not only our biological needs, but also our demands for recreation, esthetic gratification and happiness. We cannot yet specify with precision our biological needs and we do even less well with the others.

We can consider the kinds of worlds we might have that would meet our needs as a spectrum extending from the completely "natural" to the totally artificial. At one end of the spectrum would be a world in which the influence of man is essentially nil, and where he makes do with what is present. For millennia we lived just thus—the existence of man as a species is evidence that man, at least in limited numbers, can survive in such a natural world. Even if we could, few of us would exchange our modern comforts and standards of living for the vagaries and uncertainties of a world in which we passively accepted what was present.

At the other end of the spectrum is a totally controlled environment in which each of the requirements of man is provided in just the right amount at the right time. We do this now in the controlled environment of a space ship. Perhaps in the future we may be able to do so for the earth as a whole. But the spaceship environment still requires inputs of energy and materials gathered from the earth. At this point in time it is not self-sustaining; moreover we don't expect its occupants to live out their lives in its confines. Even though we might accept such an artificial environment, we have far to go before we can replace the materials and services provided by the natural world. So the real world in which we live is somewhere between these two extremes, and our goal must be to manipulate it in such a way as to meet our needs.

Man, though comparatively adaptable, has certain biologically fixed requirements and limitations. He must have oxygen to breathe, water to drink, certain kinds of nutrients. Beyond these basic essentials are certain aesthetic requirements which we cannot yet quantitatively specify—but which are none the less real.

We cannot yet meet these biological needs without certain services rendered to us by living organisms. We depend on green plants to capture energy from the sun, and combine it in organic compounds where it is stored in a form

we can draw on. In the process plants remove carbon dioxide from the surroundings and return oxygen to the atmosphere. The efficiency in energy capture is low, but the scale is vast. Other living organisms break down organic matter into smaller pieces; others ultimately return it to a mineral form in which it can again be used. Still others convert plants into other more favored forms of food. But just as nutrients and energy move from one level to another in these food chains, so too do other compounds including such disadvantageous substances as radionuclides, heavy metals, and persistent organic compounds.

The living organisms that perform these functions are aggregated into communities, the members of which are determined by their common ability to tolerate the physical conditions of the site and interactions with the other members of the community. The relationship is not passive for the organisms in turn interact with and may change the site. Their tolerance levels are not necessarily identical, but they overlap in the range of conditions present on the site. As conditions change, new organisms with tolerances that fall within the new ranges may become a part of the community; some of those originally present may be eliminated. The less rigorous the conditions of the site, the greater will be the variety of the inhabitants. It is clear that man can affect two variables, in these dynamic systems. He can deliberately select and favor organisms that directly suit his needs as he does in agriculture—in fact he can manipulate them genetically to make them better suit his needs. Second, he can alter the characteristics of the site—physically or chemically. Again he does this deliberately in agriculture by addition of fertilizers, by plowing, etc. He may also alter both variables unwittingly.

Pollution is one of the ways by which we change the quality of a site. So long as a pollutant does not exceed the limitations of the organisms present, there will be no profound change. As the alteration in conditions becomes greater, changes in species will be greater—but there will not necessarily be changes in the basic processes that take place or in the value of these to man. All of which is to say that change *per se* is not necessarily bad. On the other hand, when changes reach such a magnitude that the functioning of the community is impaired, then there is reason for concern.

So much for my comments on ecology.

It seems clear to me that environmental management must consider not only the direct response of man to pollutants, but rather must consider the effects on all the living resources he requires or uses. And because each of these living organisms in turn depends on others, our concern must extend to most of the living world.

There are two general sources of man caused pollution: wastes that we deliberately dispose of, and materials that enter the environment by inadvertence or accident such as by-products of combustion or products of normal wear or pesticides that linger on after they have served their intended use. The strategies for managing these two categories of pollutants may be very different. For the deliberate wastes there are point sources, and we can act either to change the character of the waste so that it is not detrimental, or we can try to segregate it in a part of the environment where it will not be harmful. Much of the discussion before this committee has dealt with technology for handling these problems. We have so far to go in handling such wastes that it may be academic to worry about getting our environment "too clean." It is possible to remove the wrong things because we do not understand troublesome processes like eutrophication. And it is at least theoretically possible to return sewage effluents to our waterways essentially ion-free, which, carried to an extreme in intensively used rivers, could reduce or eliminate fish and aquatic life. More to the point, it would be economically wasteful. Our real problem with these wastes is to strike a balance that will utilize fully the capacity of the environment to assimilate them, but will not so overburden the environment as to lessen its usefulness.

The inadvertent or accidental pollutants are a different matter. Many of these compounds are new to the biological world, and in some instances they resist degradation by physical and biological means. The processes that have evolved over the millenia for returning "dust to dust" do not work with some of these compounds. Some of these compounds are washed into our streams, are carried into the amosphere, are picked up by living organisms and carried in their bodies. Some of them, because of their persistence, travel vast distances. From the lead added to gasolines, we have increased the amount of lead in urban

areas, in areas close to highways, in the surface waters of the oceans, apparently even in the bodies of men. Some insecticides, such as DDT, have been found (usually in very small amounts) in fishes far at sea, in penguins and seals in the Antarctic, in snow and rain, and in the atmosphere. Some of these compounds, in relatively small amounts, are toxic to some forms of life—for example, to shrimp at less than 1 part in a billion parts of water. (Considering that shrimp, and crabs and lobsters too, are biologically much closer to the insects than to the vertebrates, it is not surprising that they are especially sensitive to chemicals designed to kill insects.) For the most part, we have not seen obvious ill effects from the quantities present in our environment. But our ability to detect change is not good, our experience has not been long, and effects there may well be.

Living systems pass on these materials from one level of life to another, often concentrating them at each successive stage. Oysters for example are able to extract DDT from water containing less than 1 part in 10,000,000,000 and concentrate it to 0.6 part in 1,000,000 in their bodies in 15 days. At slightly higher environmental levels, the concentration factor may reach 70,000 times. Even though apparently not harmed themselves, they can pass on these substances to other organisms that feed on them, which in turn accumulate still more.

The best documented case of the effects of such accumulation was at Clear Lake, California, where lake waters containing 1 part of DDD in 50,000,000 parts of water produced plankton containing 5 parts per million. Fish feeding on the plankton contained fat with hundreds of parts per million; grebes that fed on the fish died. Similar concentration phenomena have been observed in terrestrial environments.

Waste generation will continue and despite greater attention to recycling and reduction in waste production, there will continue to be a need to dispose of wastes.

To dispose of wastes in the "best" manner requires that we learn, and use, the capacity of the environment to assimilate wastes. Thus, we need to learn enough about the physical structure and processes within our environment—air, land and water—to make suitable judgments as to rates and methods of movement, capability to retain wastes segregated from the rest of the environment, effects of wastes on physical and chemical characteristics.

We also need to learn enough about the biosphere to both utilize its capabilities and protect it from damage.

Today our knowledge is not complete for any single ecosystem, though we know much more about some than about others.

There is need for a great deal of hard, grubby work—an extension of the natural history of the last century, using present-day techniques, to provide us with knowledge of just what species are where—and beyond this a refinement that quantifies their relationship; that elucidates the dynamics of the population. Such knowledge, for at least representative ecosystems, would provide us with ecological baselines against which change can be measured.

Most studies to date have dealt with effects of single pollutants, yet pollutants occur in innumerable combinations and concentrations in nature, some of which react synergistically. Most studies have dealt with short periods of time, yet some of these are nearly constant low-level presences; most studies have dealt with healthy organisms, yet wild populations are made up of young and old, healthy and ill, and almost always they are under some stress or another which may make them more susceptible to pollutants.

Waste disposal, and control of other pollutants too, must eventually be based on a knowledge of what happens with what concentration of what pollution where, a judgment of what we can accept in environmental damage, and information on the costs of control. Eventually "on-line" computers programmed with suitable models and fed with appropriate environmental data, perhaps gathered by remote sensing techniques, may well direct our actions. In the meantime, construction of models will help us select proper priorities for our research efforts.

A number of Bureaus in the Department of the Interior are conducting research and acquiring data, and developing methods, including simulation and modeling, that will provide necessary information for sound environmental management. The appended statement of the Geological Survey illustrates such activities related to the physical environment.

Both Bureaus of the Fish and Wildlife Service, as well as the Federal Water Pollution Control Administration have research underway on the biological effects of pollutants. Some of the problems they face are severe:

Which of the thousands of pollutants should be tested first? What combinations? For how long a time? At what concentrations? Is there a threshold below which there is no effect, or no uptake?

What species? At what stage in the life history?

If oysters containing X parts per million of pollutant "A" are safe for man to eat, are these levels harmless to the oyster?

These questions relate largely to effects on individuals. But the same questions apply, and answers are needed, to populations and to ecological systems as well. It may well be here that our ignorance is greatest, and our needs most intense.

Thank you for your attention. I should be glad to attempt to answer questions.

APPENDIX 1

(To statement by J. L. Buckley before Committee on Science and Astronautics)

ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY RELATED TO POLLUTION ABATEMENT TECHNOLOGY

Better knowledge of scientific laws, basic principles, and environmental processes must form the basis of improved understanding and better control of our environment, including pollution abatement and all other conservation measures. A great variety of basic data must be collected to improve knowledge of our environment. Also, research must be done continuously to understand better the processes which control the complex responses of environmental elements to the stresses of nature and man.

In the field of water resources, the U.S. Geological Survey is the nation's principal basic data collector, and currently is increasing its efforts to collect the data most likely to serve the needs of those who are trying to improve our environment. It also is the principal Federal agency concerned with research on water resources, as such. This entire research effort is aimed at better understanding of fundamental processes which must be controlled or lived with to cope with environmental problems.

BASIC DATA INPUT TO POLLUTION CONTROL

For many years water data have been collected primarily for planners rather than for water managers faced with rapidly changing problems. Therefore, they have been collected carefully, but by rather time-consuming methods. To cope with today's water problems, one must have data essentially on a daily basis in order to predict critical situations, and to deal with them before irreparable damage occurs. The Survey is placing great emphasis on automatic monitoring, better water resources coverage, computer processing of data, and a variety of rapid methods of information release. Achievements in data service will permit increased efficiency in the control of pollution.

THE BEARING OF PROCESS RESEARCH ON POLLUTION ABATEMENT

Failure to cope with certain serious pollution problems, such as algal bloom, often can be traced to lack of knowledge of the controlling scientific principle or process. For example, biological stoichiometry (balance of aquatic organisms) now is known to be the key to blooms of this kind, and it is thought that the basic "law of the minimum" determines whether or not undesirable growths will occur. Unfortunately, analytical methods still are so deficient, and knowledge of biological processes so uncertain, that one cannot predict accurately exactly what set of circumstances will cause algal bloom. Therefore, he cannot devise preventive treatment which is applicable in all cases. Research by the Geological Survey on nutrient cycling processes, solutions geochemistry, and analytical procedures are aimed at filling gaps of this kind.

SIGNIFICANCE OF HYDRAULICS IN QUALITY CONTROL

It generally is conceded that practicable water quality standards are a first step toward improving our water resources. But to set such standards requires knowledge of extremely complex interactions between hydrodynamics and water quality factors. Until this relationship is properly understood, it will be impossible to set any completely satisfactory standards. The Survey is placing

great emphasis on relationships of flow, seasonal changes, and water quality in an effort to provide this knowledge.

GEOCHEMICAL RESEARCH AS RELATED TO POLLUTION

Ground-water systems, impounded water, and estuaries are subject to unwholesome quantities directly related to a variety of biological, chemical, and geochemical processes. Some of these processes could be inhibited or counteracted if they were properly understood. The Survey has a considerable research program aimed at understanding such subjects as the solution chemistry of sediment-water interfaces in lakes, and acid-producing processes in mines. Mine acid and accompanying serious iron contamination result from reversal of a massive process of nature originally responsible for pyrite deposits, which now are primarily responsible for the mine problems. It is not known whether these processes occur in both aerobic and anaerobic environments, nor whether it is possible to inhibit or reverse the process by proper catalysis, bacterial seeding, or other encouragement. Geochemists of the Survey are working to understand such processes and to demonstrate, by pilot applications, what might be done to reduce related pollution.

REMOTE SENSING POSSIBILITIES

The massive expansion in population, industry, and urbanization, and the attendant waste disposal problems, mean that much information must be collected on a large and relatively inexpensive scale of we are to keep up with the rate of problem development. Remote sensing of pertinent environmental factors is the only answer to this situation. The Survey's Remote Sensing Hydrologic Applications Program has an extensive plan for surveillance of lakes, hydrodynamic studies of estuaries, and other subjects, which well could result in breakthroughs of understanding of environmental phenomena.

APPENDIX 2

COMMENTS ON ISSUE D(2) OF "ISSUES FOR THE CONSIDERATION OF THE CONGRESS," PAGES 15–17, "REPORT OF THE RESEARCH MANAGEMENT ADVISORY PANEL"

"D. The Scientific Basis for Pollution Policy.

"(2) What do we need to know about movement of ground water to permit deep well disposal of wastes? Similarly, do we know enough about oceanic circulation and marine ecology to permit deep sea disposal of wastes?"

DEEP-WELL DISPOSAL OF WASTES

Until the utopian goals of waste management are realized—complete and productive re-use of waste products or total removal of wastes from man's environment—compromises must be acceptable. This means reduction of waste volumes to the maximum practicable extent and discharge into those parts of the environment that are farthest from the biosphere. The fluid-filled void space of the geologic subsurface contains storage reservoirs for liquid wastes that have been out of direct contact with surface processes for millions of years. Injection of liquid wastes into this inner space provides the opportunity to remove noxious materials from contact with man almost indefinitely.

Deep injection of wastes is a useful alternative to disposal into surface or near-surface potable or usable waters. It is not a panacea and is presently an expensive and often uncertain alternative. Although the general methods are well known and are based on proven engineering concepts, confidence in feasibility judgments and long-term acceptability at a given site requires information in a degree of detail that is seldom readily available. This includes (1) a knowledge of the subsurface rocks and their contained fluids, (2) the dynamics of the flow system of which all subsurface fluids are a part, and (3) possible adverse geochemical interactions among waste fluids, native water, and reservoir rock, dangerous hydraulic fracturing and possible adverse effects of waste fluids on geologic processes such as movement in faulting zones.

Considerable geologic and hydrologic research is required to provide a better basis for evaluating underground waste disposal sites. Geologic and hydrologic research, data collection, and analysis activities of the Geological Survey must make major contributions to attaining the necessary information. Expansion of some activities, particularly in the areas of age dating of deep ground

waters, the geochemistry of deep flow systems and fluid mixing systems, and effects of deep disposal on the hydrodynamics of saline water systems, would improve prediction of long range effects of deep disposal, particularly in the general area of adverse effects on water and other mineral resources of possible future importance.

INJECTION OF GASES INTO THE GROUND

The storage of natural gas in man-made or natural subsurface reservoirs is an established practice. The methodology developed, as well as the scientific principles learned from research on the behavior of gases in porous media, indicate that major breakthroughs in reducing air pollution at some localities might be possible by injection of low volume waste gas streams into the ground. Disposal might be at shallow depth into unsaturated void space (principally in arid regions of the west) or at greater depth into reservoirs that would depend on creation of a gasbubble.

Shallow disposal into air-filled void space between the land surface and the zone of saturation would depend not only on the presence of an impermeable layer near or at the surface, below which gases could be injected, but would also require detailed analysis of gas migration rates in the permeable reservoir rock as well as through the confining layer. The attractiveness of the method stems principally from the fact that rates of transport of gases injected into the ground are much lower than rates of transport in the air and that decontamination may result from adsorption of gaseous contaminants on the solid matrix of the disposal reservoir or by filtration of particulate matter.

Deep disposal would be closely analogous to methods for storing natural gas, using a depleted structural or stratigraphic natural gas reservoir or locating a barren structure by drilling and testing, which could be used as a disposal reservoir.

The energy requirements for such a system are high, but for gases that present problems of cleanup by filtration or other conventional treatment, and that can be segregated into a concentrated low-volume stream, the method has great potential for alleviating critical air pollution problems.

A great deal of research is necessary in order to develop the method, particularly on the interaction of waste-gas materials and earth materials (including water) and detailed information on any proposed site is necessary to determine feasibility. Current research on the physics of flow of gases and liquids in the unsaturated zone above the water table will contribute to an understanding of the problems underlying shallow disposal. The research areas that are important to deep disposal of liquids are also important to gas disposal.

OCEAN DISPOSAL OF WASTES

Our knowledge of ocean circulation is far from complete. Yet we know enough to say that under present circumstances the open ocean is a much more suitable waste treatment basin than the rivers and estuaries. However, costs are higher, and we should not repeat past mistakes by assuming that indisicriminate dispoal of wastes in the open sea is a final answer. If it is necessary to continue to view wastes in the negative sense, as useless material which must be discarded, then the ocean can be used safely to dump large amounts of wastes provided that this is done under adequate control. Eventually, it seems that we must find imaginative new ways of waste treatment based as far as possible on the concept of recycling and re-use.

Mr. DADDARIO. Our next witness is Mr. Henry W. Riecken of the Social Science Research Council.

STATEMENT OF MR. HENRY W. RIECKEN OF THE SOCIAL SCIENCE RESEARCH COUNCIL

Mr. RIECKEN. Thank you, Mr. Chairman. It is a pleasure to have a chance to talk to the committee. I speak for myself as a social scientist rather than as the Vice President of the Social Science Research Council making an official statement. I'm glad to speak to

the question of whether the social sciences can usefully contribute to the abatement of pollution and what ways they might do so.

I do not have a prepared statement but I prefer to work from notes, Mr. Daddario, if that will be acceptable to you, and I shall try to be brief. I know that the committee has sat for many days and listened to much testimony. It has sat a long time this morning and probably would welcome brevity.

Furthermore, I think that the social sciences have not as yet done very much to contribute to the solution of pollution problems and hence there is perhaps not much for me to say. I'm reminded of the words that General Eaker had to say when he landed the first contingent of B–17's in a small English village in 1942 and was asked to make a speech to the inhabitants. He thanked the local people very much for their warm welcome, and added: "When we have done some fighting, we will do some more talking." Then he sat down.

I am not an expert on pollution, Mr. Chairman, but I have tried to follow some of the studies of the subject and to give some thought as to how social sciences might help to make recommendations for the abatement of pollution.

We haven't found a fully satisfactory role for social sciences as yet. As my first suggestion, Mr. Chairman, I would recommend that a good way to get social sciences involved and thinking about these problems would be to get social scientists appointed to advisory boards and study committees that have looked into pollution problems.

I notice, for example, no social scientists named on the PSAC Environmental Pollution Panel or on the subpanels thereof. There are only one or two among the participants in the discussions conducted under the auspices of NAS-NRC Committee on Pollution.

The effective participation of social and behavioral scientists in efforts to abate pollution require development of a body of knowledge. The development of a body of knowledge, a body of interested people who are aware of the problems and the techniques of pollution control, is essential so that social scientists can both learn about where they can be useful as well as suggest ways of formulating the problems.

In other words, I think you learn about a problem by participating in groups that are working on the problem. I think it is essential to have social scientists participating.

I would suggest that there are at least four ways in which social science may contribute to the study of pollution and its abatement. Let me briefly enumerate them and then I will go into some detail on each.

The first way is by the analysis of the economic, social, and human context in which pollution occurs, and by clarification of the forces that produce pollution or allow it to occur.

The second way is through the assessment of popular understanding of pollution and its causes, and asessment of popular acceptance of measures for its abatement.

Third, I think that social scientists can contribute through the invention of institutional devices for effective control of pollution, and, fourth, they can contribute through the invention of techniques for community education and action.

Let me take up these points separately. The first one in the matter of the analysis of the economic, social and human context in which

pollution occurs and a clarification of the forces that produce pollution or allow it to occur.

Now, social scientists are not particularly good at biochemistry or combustion engineering and ought not to work on the physical aspects of pollution per se. What they ought to be thinking about is the sociological context in which pollution takes place. What are the human attitudes, interests, inhibitions, habits, beliefs, and so on that affect the processes of handling air, water, waste, containers, food, and the like.

Let me take as an example one that comes through some public health experience that I happened to have had. One of the most serious problems in underdeveloped countries is a disease called weanling diarrhea, which affects children from 6 months to 3 or 4 years of age. In addition to malnutrition, retarded physical and mental growth, increased susceptibility to respiratory diseases, and other infections are the symptoms of this enteric affliction. It often terminates in death.

The origin, transmission and behavior of this disease are being studied and there are a good many open possibilities. It might be a dietary deficiency, a virus infection, bacterial infection, or other causes. An interesting question is how this disease moves about among the population. It was a behavioral study that showed an intimate association between the prevalence of diarrhea and the availability of water.

Now, if water is available within a hundred meters of the home, the prevalence of the diarrhea is remarkably less than if the water is more than 100 meters away. This finding comes from a study done in Costa Rica by the Louisiana State University School of Medicine. There is not much difference in prevalence whether the water is piped into the individual house or available in a public spigot or even at a well as long as it is near the house. It is distance from the home that counts. This suggests very strongly that the mode of transmission is hand to mouth in a very literal sense. That is, the cleanliness of the mother and child are greater if water is available so that they can keep themselves clean, and therefore keep the infants' food and toys and other things that children put into their mouths clean.

Now, it is probably failure of personal hygiene through the lack of water that is one of the major means of transmitting whatever the causative agent of this disease may be. Behavioral study suggests very clear clues as to how the disease is transmitted, and maybe how it can be partially controlled.

Now I want to take another example of social science research and show its possible contribution to the study of pollution. Much attention has been paid to the possibility of reducing air pollution in urban areas by altering commuter habits, especially by shifting people from private automobile to public transportation and particularly from vehicles propelled by internal combustion engines to some other kind, preferably electrical.

Now, economists have been doing some thinking about some of these problems and doing some research, examining the value of time, the attractiveness of mode of transportation and questions of subsidy or cost of alternative modes of transportation.

The private auto as I'm sure the committee knows from personal experience, is a very attractive mode of transportation for its convenience. A study in Chicago, for example, showed that about 30 percent of the automobile commuters walked one block or less from the place they parked to the place where they worked, and 40 percent more walked less than three blocks. That leaves only 30 percent of the commuters walking any sizable distance from where they leave their cars.

Buses, streetcars, trains, have to be very convenient or cheap, or rapid, or in some other way superior to compete with cars. No doubt technology can make more rapid buses, streetcars, trains, monorails, given time and investment and superior speed might compensate for some of the attractiveness of automobiles.

But, let me cite one study done in Chicago by Leon Moses and Harold Williamson. They analyzed interviews with a sample of commuters in the Chicago area by the Cook County Highway Department. Their analysis concentrated on a subsample of commuters; namely, those who preferred automobile commuting to other modes of transportation. Moses and Williamson used their data to estimate the amount of money by which cost of auto trips would have to be increased in order to divert 50 percent of the commuters to an alternative mode of transportation. They also estimated the converse, the amount by which the cost of the other modes of transportation would have to be reduced in order to divert 50 percent of the motorists to them—i.e., to common carriers. I won't try to reproduce the data in detail, but just summarize their findings. Essentially the question is: What would it cost to induce half of the auto commuters to shift to a common carrier? What subsidy would you have to provide for the public transportation system that would reduce fares to an attractive enough level to produce this impact on automobile traffic?

I would like to read part of the conclusion of the study: "It is evident that negative prices would be necessary on all modes of public transportation in order to divert at least 50 percent of those currently making the trip to work by car."

In other words, they estimated that it would be necessary to pay auto commuters about 40 or 50 cents per "el" or bus trip in order to get them to use common carriers, and therefore reasonably conclude that: "the possibility of reducing significantly auto congestion by reasonable reductions in the price of public transportation appears slight."

Now, what do these authors think would happen if public transportation were free? They say their results suggest that if such an experiment were carried out in Chicago, less than one-fifth of the auto commuters would be diverted to common carriers.

Would that be a worthwhile reduction? Well, on this point the social scientist turns back to the engineer and asks how effective a reduction of 15 or 20 percent in the number of cars each day in downtown Chicago might be. I might say also that the social scientists also tend to turn toward Detroit to ask what would be the effect of reduction of this size in the demand for automobiles in the Chicago area?

An alternative to lowering the price of public transportation is, of course, raising the price of auto transportation through various means

such as selectively higher toll charges during the morning and evening rush hours; higher parking charges; greater gasoline taxes; or mileage meters like taximeters, which would have to be used in particular zones of the city which were most crowded or most polluted. Such meters would be designed to register the number of miles traveled by the vehicle; they would have to be used in certain prescribed downtown areas; and would in effect be computing the bill for the driver who wanted to take his car (or truck) downtown. Similar discriminatory taxing and pricing measures designed to decrease the concentration of automobiles in crowded downtown areas are entirely conceivable.

They are, of course, not likely to be terribly popular, Mr. Chairman, with the traveling public, but this is one of the things I think we have to face if we want to talk about how we control pollution. One of the ways to control pollution is to price it out of the market.

I would like to note in this connection that the results that I have reported on the Chicago study of commuters are based on the assumption that the common carrier, the competitive common carrier transportation would not be substantially improved over what it presently is. Now, of course, the results would change if there were more rapid, more convenient, more attractive somehow, more competitive common carrier transport for at least Chicago, and indeed other major cities.

Let me move on now, Mr. Chairman, and turn to the contribution I think that the social sciences can make in the asessment of popular understanding of the causes and results of pollution, and popular reaction to measures proposed for the relief of pollution. Public opinion polling techniques can be used to get the answers to such questions as:

Does the public at large know the extent of and the nature of pollution in its various forms now?

Do people understand the causes of pollution or have theories about its causes or prevention? Sometimes people do have clear, but not always correct, ideas of causes and consequences. It is wise to know about these "vested ideas," which sometimes have to be corrected before effective action can be taken.

How much do people care about various kinds of pollution? Do they worry about health, about the appearance of the environment? What kinds of pollution bother people most? Perhaps the popular appreciation of water pollution or air pollution is much less than the understanding of it is in Congress or among scientists and engineers.

Do people worry about the effects of pollution on health? Are they concerned about costs and other economic effects of pollution or of measures for abatement? How much popular support is there for moves to eliminate or modify any sort of pollution?

Leaders in Congress and the scientific and engineering professions may not always accurately reflect the opinion of the majority of the population in the appreciation of the importance, or the size and seriousness of pollution problems. I would say in fact, it is quite likely that the leadership of the Nation is way out ahead of popular understanding and appreciation of these problems. That is, after all, the job of leadership.

Leaders may attach greater importance to some problems than most people do. It is useful for leaders to know where they stand when they try to mobilize popular support for efforts to change a situation.

Polls can measure the readiness of people to accept the inconvenience or costs of abating pollution. How much are people willing to pay for clean air, or rather how much are they willing to pay for not contributing to dirtying the air through their house furnaces or their cars?

It is also possible, I think, for polls to measure possible attitudes toward the products of an improved pollution-abatement technology, and here we may encounter some very fundamental negative attitudes.

I mean, Mr. Chairman, attitudes toward waste materials; for example, how willing would people be to accept reprocessed waste materials in various forms, for example, as drinking water? Not everybody has the same objectivity toward such material as astronauts have. I'm sure that pollution abatement measures are going to run into some quite interesting and, as I say, fundamental human attitudes.

I think these poll results can be used as bases for educational campaigns, for anticipating and perhaps warding off difficulties in the acceptance of new technological devices for pollution control.

I would advise against using public-opinion polling as a means of inventing techniques for the control of pollution. I think general experience is that the majority of the American public, are very good as critics, very good in reacting to the ideas of others. But, since they have not had the opportunity to give detailed, informed thought to a problem, are not as good at inventing things as experts are. The public is better at criticism than they are at design.

A third kind of contribution that social science can make is the invention of institutions and administrative arrangements for the regulation of pollution.

Air and water pollution do not conform to political boundaries. Existing types of jurisdiction cannot always deal effectively with pollution problems. It has often been said that, in order to control pollution effectively we need new kinds of intergovernmental agreements and very possibly new regulatory agencies or new powers for existing agencies. In this area social scientists have already made some contributions for they were influential years ago in pointing out the need for better coordination of responsibilities among the different levels of government: Federal, State, county, municipal and so forth. And as a result, the Congress established in 1959 the Advisory Commission on Intergovernmental Relations. This is a permanent, bipartisan, national agency charged with studying and making recommendations on means for coordinating and making more effective the actions of these several levels of governmental authority.

The Commission is made up of Federal legislators, Cabinet officers, State Governors, county officers, mayors and representatives of the public at large.

This Commission has already been active in the pollution field. In 1962 it issued a report entitled "Intergovernmental responsibilities for water supply and sewage disposal in metropolitan areas", which identified the problems of State and local relationships involved in planning and operating water supply and sewage disposal systems. It

suggested several institutional innovations. For example, the idea of vesting responsibility for all water resource planning in a single State agency and in giving urban communities in that State representation in the agency.

Another innovation was the establishment of areawide sewer and water authority for metropolitan areas. A third was legislation to provide for State regulation of individual wells and septic tanks in urbanizing areas. The Commission came to the conclusion that this latter was a very important source of pollution as the suburbs expanded faster than municipal water and sewage systems did.

The Commission also recommended that there should be an evaluation of Federal regulatory authority and incentives for reducing industrial pollution. On the basis of this recommendation, the Department of Health, Education, and Welfare did contract with the Institute for Public Administration to do a report in industrial incentives for water pollution abatement, which report was issued in February of 1965.

Mr. Chairman, the work of this Commission seems to me to exemplify but not to exhaust, the contribution that social scientists can make in this area. I simply cite these activities as a concrete instance of how the procedural and institutional framework for regulating pollution can be improved.

A fourth way in which I think social scientists may contribute is to devise new and improved techniques of popular education on problems of pollution and ways for reconciling opposed views or disagreements, ways of reducing tensions and promoting community harmony as well as the will to work at the task of abatement.

Mr. Chairman, these will not be easy things to accomplish. I do not wish to forecast trouble unduly, but I'm struck by the similarities between the techniques for reducing certain kinds of pollution and some of the problems encountered in public health practice, specifically and especially in adding fluorides to drinking water. This is a matter which public health officers and social scientists together have had considerable experience in the late 1940's and in the 1950's. This committee may be well aware that fluoridation encountered sharp, vigorous and effective resistance in many communities. Fluoridation was often defeated the first time it was brought up and is still not used in some communities.

Resistance to it was not always well informed, but the advocates of fluoridation sometimes made a serious mistake when they assumed that everybody who resisted fluoridation was ignorant, superstitious, reactionary, or just plain crazy. Now, that was far from true. There were some, and there still are some, people who simply are prudent and curious about the long-term effects of fluoridation. Still others were resistant because they resented the air of superiority assumed by some engineers, scientists, and public health workers. Other people objected to being experimented on.

Still others were genuinely ignorant (not stupid) about fluoridation and they wanted to know how the process worked and whether there were safeguards against error in it.

I think it is the job of applied social scientists to devise better ways of explaining innovations to the affected communities; to help to recon-

cile people who are disaffected for the wrong reasons; and to help insure that those with legitimate complaints, reservations and hesitations have a chance to be heard and to affect the outcome.

In this respect, I can say that there are a few groups of applied social scientists working on problems of community organization and trying to invent and improve methods of representing truly the will of the people as well as dealing with fears, concerns, hostility and disaffection. In particular I mention work of the National Training Laboratories in developing techniques of community organization and action.

Finally, by way of an educational innovation, I suggest that perhaps there might be created a new social role. Mine is not a brandnew suggestion, I'm sure. But I am not sure it has been made before in connection with pollution abatement. The role is that of "neighborhood agent," so to speak, comparable to that of the county agent in rural areas, who would act as a direct contact between pollution control agencies and those who pollute. He would visit individual householders or tenants and bring them advice, technical help, refer them to further sources of information or help, answer their questions, help to motivate them to keep their environment clean. This is a necessary role, I think, especially in parts of cities where the physical environment is not beautiful, neat or clean to begin with; and when such neighborhood work is combined with the control of industrial and municipal pollution, local efforts can have a great deal of immediacy and personal meaning to neighborhood residents.

In conclusion, Mr. Chairman, I would like to say that I see some similarities as I have implied before, between problems of pollution abatement and some of the problems of public health that have been worked on successfully for the last three or four decades.

In the first place, many public health problems were and still are pollution problems, especially those of various waterborne enteric diseases, often associated with management of human and animal wastes.

Contagious diseases such as smallpox, tuberculosis are a second example, and, infectious diseases with nonhuman reservoirs such as typhus, malaria, hookworm and some others still not under control. These problems seem to me have yielded to a combination of methods and means rather than to a single technique, a single science, or single means of control.

Hookworm, for example, has virtually disappeared because of improved sanitation and disposal of fecal matter, better diet and the more widespread wearing of shoes, the latter being partially an economic matter and partially customary.

Smallpox has been virtually eradicated because of effective research on immunization, the development of vaccination, the gradual public education of most of the Nation and the establishment of legal requirements on those entering the country.

Typhoid fever has disappeared because of better management of water supplies, because of investment in water storage, purification and distribution systems, because of improved management of wastes, and because of research of method of transmission of the diseases.

Milk, which was so often in the earlier centuries a means of transmitting enteric diseases, now is a safe and wholesome product because

of a combination of many factors. Research and technological developments on pasteurization; the legislation of standards for the handling of fresh milk and testing of cattle; the education of farmers and milk producers in correct techniques in handling; the organization of means for carrying out dairy herd inspection through technicians and provision of testing services; investment in apparatus and machinery for keeping milk clean; and finally enforcement of standards through regulatory agencies.

Progress in public health, Mr. Chairman, has been made through research, through the development of technology, through the education of the public, through investment in apparatus, machinery, and labor time needed to do the job right, through legislation of standards or rules and through enforcement through regulatory agencies.

And, I think it is going to be a combined attack of this sort, a varied attack employing many different means that will help us to solutions for pollution problems as well.

Finally, Mr. Chairman, I want to thank you again for the opportunity to make these remarks and, speaking as a citizen, I would like to commend this committee for its foresighted concern and its serious and dedicated interest in the problems of pollution of our environment.

Mr. DADDARIO. Mr. Riecken, I'm extremely happy that you have come here because your statement certainly gives us some guidelines to go by. It will be helpful to us as we further analyze the problem of pollution after the testimony is all in. You have shown us the steps we must take to accomplish our end objectives, but I wonder what you might suggest as to bringing public opinion to bear on those parts of the pollution problem for which available technology could be applied now?

Dr. Thomas Malone, who comes from my own city of Hartford, said that when he flew over the city of New York he could hardly see it because of the air pollution. He made the observation that we did have available to us the means to eliminate a great deal of this if we only had the desire and if we could get support from the public.

In some cases, then, we have already gone through the research and development steps. We are just not able to bring together the catalytic forces necessary to have the public decide that we have had enough of this.

Mr. RIECKEN. Mr. Chairman, I'm sure that the work of this committee and the publicizing of it through newspaper stories and through other mass media will in itself be a great deal of effect in educating the public and calling attention to the problem.

I'm sure that the long-term education of our growing population of young people is something that ought to be begun at once. I'm not going to suggest special courses in pollution, but I suggest strongly that there be incorporated in elementary and high school instruction in such subjects as geography, biology, and social studies some attention to the relationship of man to his natural environment and the change in that relationship as population density increases and as urbanization increases. This is a subject that could be given a great deal of attention. I'm sure that the resources of educational television for selected programs on pollution abatement would be of enormous assistance in adult education.

Now, I think in addition to that, Mr. Chairman, you have to look at where you can do most with the least effort. And, here I proceed with great tentativeness because I am not that well acquainted with the facts. Let me make a hypothetical case that a large share of the pollution of New York City air, which I too have noticed in the good old days when you could easily fly to New York, the pollution of New York City air may be caused by a relatively small number of pollutants. If that is true, it would be more effective to work with regulatory or economic sanctions; that is, laws about pollution abatement or fines, or other economic sanctions for pollution. If the number of sources of pollution are few and concentrated, a widespread educational campaign hardly seems necessary.

Popular education, I think, is an important component of pollution control, but it is a long-term component, and I think we ought not expect fast, big results from it. I think we are going to get faster, bigger results from some other measures such as better enforcement of present regulations on economic sanctions against massive pollution.

Mr. DADDARIO. And, the cost factor which you touched on before does, of course, enter into the public acceptance of this solution.

Mr. RIECKEN. I might go back to a question Mr. Vivian asked and I found very interesting. I'm sorry he isn't here. He asked Dr. Buckley the following question: Suppose there were a better insecticide than DDT or one more readily degradable but it cost more, what would induce farmers to use it? I think it is a very reasonable question. It seems to me there are only limited number of ways in which you would go about dealing with this problem. One is, I think, to persuade manufacturers not to make a nondegradable insecticide. This would be voluntary compliance by the source of the pollutant. I think something like this has been done in the nonsudsing detergent development. You get action by going to the source of the polluting material rather than to the ultimate user.

Now, if you have to go to the ultimate user, if you can't somehow get control through producers, it seems all you can do is either to have laws restricting the use of nondegradable insecticides; or else you can have economic solutions, such as subsidies to reduce the price of degradable insecticides, or taxes to increase the cost of nondegradable insecticides.

That seems to me to be the range of solutions possible for us to adopt in the kind of society that we have.

Mr. DADDARIO. I regret that we have tried to crowd three witnesses into our schedule today and have gotten to the point where we have a quorum call which forces us to close this hearing. There are a number of questions I would like to pursue further, and we will, if we can take advantage of you by sending them to you. If that is not satisfactory, we might have a chance to sit down with you on an informal basis before we conclude our hearings.

Mr. RIECKEN. I will be more than glad to do that.

Mr. DADDARIO. This committee will adjourn until 10 o'clock tomorrow.

(Whereupon, at 12:30 p.m. the committee adjourned until 10 a.m., Thursday, August 11, 1966, same place.)

THE ADEQUACY OF TECHNOLOGY FOR POLLUTION ABATEMENT

THURSDAY, AUGUST 11, 1966

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The committee met, pursuant to adjournment, at 10:17 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. ROUSH. The committee will be in order.

Mr. Daddario will join us shortly. He is meeting briefly with the chairman of the full committee.

Our first witness this morning is Mr. John O. Logan, executive vice president of the Olin Mathieson Chemical Corp., who is speaking on behalf of the Manufacturing Chemists Association.

Do you have some associates you would like to introduce to the committee, Mr. Logan?

Mr. LOGAN. Yes; I will, Mr. Chairman, as part of my comments.

Mr. ROUSH. You may proceed.

Mr. LOGAN. Thank you.

STATEMENT OF JOHN O. LOGAN ON BEHALF OF THE MANUFACTURING CHEMISTS ASSOCIATION

Mr. LOGAN. As the chairman has mentioned, my name is John O. Logan. I am appearing on behalf of the Manufacturing Chemists Association, hereafter referred to as MCA, a nonprofit trade association of 190 U.S. corporations, large and small, that collectively represent more than 90 percent of the productive capacity of the basic chemical manufacturing industry in this country. I am executive vice president, corporate, Olin Mathieson Chemical Corp., and currently am chairman of the executive committee of the association's board of directors. Accompanying me are three technical specialists who are full-time employees of three other member companies.

On my immediate right, Mr. James H. Rook, director of industrial hygiene, American Cynamid Co., who is currently vice chairman of the MCA Water Resources Committee.

On my left, Mr. Jerome Wilkenfeld, manager of environmental, health, Hooker Chemical Corp., who is a past chairman of the water resources committee and presently chairman of the MCA Air Quality Committee.

And on my far right, Dr. John A. Zapp, director, Haskell Laboratory for Toxicology & Industrial Medicine, E. I. du Pont de Nemours & Co., who is past chairman of the MCA Environment Health Advisory Committee.

Before addressing the subject of the hearing directly, I would like to develop some perspective on "chemicals" in relation to the environment. All too often we are prone to overlook the fact that the natural environment itself is made up of a wonderful array of chemicals to which life as we now know it has become adapted. This chemical environment, entirely apart from manmade contributions, is far from being uniform and constant from time to time and from place to place. Our need is to maintain the variations in the environment so that by either type or degree they are not injurious to our various purposes and normal desirable life patterns will be sustained.

Many manmade chemicals simply duplicate those found in nature, while others are the product of human invention. Many are comparatively simple combinations of the elements, while others are highly complex, rivaling in complexity some of the chemical components of the human body.

Relative simplicity or complexity of chemical structure has no correlation with the potential impact of a chemical substance on the environment. None is toxic per se, and yet none is wholly without potential for adverse effect. Chemicals numbering in the thousands have been cleared for use as food additives after exhaustive testing, some with limitations carefully prescribed, yet an excessive portion of common table salt can be lethal to anyone.

In dealing with the problems of environmental controls, our greatest lack is an adequate understanding of acceptable quality levels. The average person might think it strange, but specialists in air and water chemistry would be the first to admit an inability to define "clean air" and "clean water" in precise terms.

Thus it is vitally important to bear in mind that the mere presence of any particular chemical substance in the environment should not automatically be regarded as undesirable. Water containing fluoride from natural sources led to the discovery of dental caries prevention and ensuing fluoridation of water supplies. There have been recent observations that water hardness; that is, water containing calcium and magnesium salts, may lessen the likelihood of cardiovascular deterioration. Of course, there must be a definition of how much is beneficial, or where benefit may be lacking, how much may be tolerated without adverse effect.

This leads to a simplified concept of pollution as being a condition where "too much" is present. It is greatly to be hoped that in our extensive programs of pollution abatement and control, the objective will always be to prevent or eliminate that increment which results in there being "too much," as contrasted with working toward the irreducible minimum. Although it may not be currently a wholly popular concept, the capacity of our environment to accept waste releases—below the too-much level—is itself an exceedingly valuable natural resource. It would be technically unsound and economically wasteful not to make proper—and I want to emphasize "proper"—use of it. It is my firm conviction, and that of the industry I represent, that society cannot afford the cost of control for control's sake.

Certainly we should not compromise with health protection, but many of our most objectionable environmental conditions are not health matters. In such cases, the remedial needs differ widely from place to place. Although administrative convenience might be served by having uniform requirements on discharges of similar charter, this, too, would be economically wasteful as a general policy. The resultant quality of the environment for its continuing beneficial use is what's important.

Premised on the foregoing philosophy, let me now go to the question of the adequacy of technology for pollution abatement and control. Earlier I referred to lack of definition of environmental quality. Obviously, this complicates judging the adequacy of applicable technology, for it means we really do not know what we ought to shoot for.

Be that as it may, we can tackle gross problems and undertake what obviously needs doing, and learn more about ultimate refinements as we go along. While there may be some gaps in existing technology to deal with even the grosser aspects of pollution, we believe that much progress can be made with a stern application of what we now know. Although we shall always be interested in decreasing the cost, this is much more likely to come about gradually by evolutionary development from a combination of operating experience and constant research attention than by massive research effort scattered along a broad front. In order that the remedial cost burden not be unnecessarily great, it will be helpful to set interim objectives at conservative levels, with subsequent tightening as scientific evidence and expert opinion provide justification. Also, as reuse and recycling of resources are increased, levels corresponding to "too much" may be expected to become progressively lower.

While the chemical manufacturing industry certainly has further contributions to make to added progress, it has a substantial record of past attention to environmental controls. A 1962 survey brought out that 125 member companies of MCA had invested $212 million in air pollution control facilities and $263 million in water pollution control facilities, and was spending $64 million annually to operate them. Projected additional investment for such facilities over the ensuing 5 years was $119 million. More than 95 percent of the nearly 10-billion gallon daily waste water volume from the 875 reporting plants met the public agency requirements in effect at that time.

MCA has had an organized Water Resources Committee active for 30 years, and an Air Quality Committee active for more than 15 years. They have prepared technical manuals that have had widespread distribution. They have planned seven educational 1-day workshops within the past year, and arranged for 4 week-long seminars providing instruction in the most up-to-date techniques for chemical waste treatment, with six additional seminars scheduled for the coming year. The workshop programs are designed to encourage participation by, and interchange with, public agency personnel; and the regular meetings of the two committees are purposely held in various States so as to receive and confer with State and local agency officials.

Inasmuch as environmental controls by the chemical industry are but extensions of applied chemical engineering, it should not be surprising that we are confident of being able to devise and use adequate

waste treatment and control methods, although the immediate cost of doing so may not always be favorable. Often this calls for particular adaptation of general techniques, illustrations of which were given in MCA testimony before the Special Subcommittee on Air and Water Pollution, Senate Public Works Committee, on June 24, 1965. I will not repeat those details at this time.

The industry survey referred to above revealed that those same companies were spending more than $8 million annually on air and water pollution control research. In the recent past MCA underwrote a 5-year research project, now concluded, at the Franklin Institute on taste and odor in water, and is now in its third year of sponsorship of a 4-year program at Washington University in St. Louis on the behavior of organic chemicals in the aquatic environment. Also, MCA has joined with several other trade associations in sponsoring research on emphysema by the Industrial Hygiene Foundation.

From these references it is self-evident that we see the need of continuing research. Indeed, in MCA's expanded environmental health program announced about 2 months ago, a considerable portion of the projected funds are being planned for greater research effort on behalf of the chemical industry. In appearances before congressional committees, our witnesses have supported Federal research in this field, and we fully expect to continue to do so. A valuable dividend from research activity is the development and training of technically qualified personnel, already insufficient in supply to carry on these vital programs.

Because of its usefulness to everyone, research efforts on determining environmental criteria would seem to be a prime area for Federal research attention. Another relates to developments which are most needful for use at publicly owned and operated facilities, for example municipal treatment works, and which may not readily lend themselves to commercial interests. The greatest stimulus for research by industry and the private sector is the potentiality for capitalizing on the outcome of research endeavors, whether it be directed toward cost reduction in relation to a company's internal operations or marketing of technology to others. Especially in the latter, patent protection can be a vital qualification for inducing research interest; lack of it may actually hamper new developments. A new idea equally available to everyone may suffer lack of attention because of the unprotected risk involved in reducing it to practice.

Except in programs of giant proportions, such as your own space exploration program, it is our impression that greater opportunity for industry to engage in research supported by Government contract would not generally be a substantial stimulus to progress. On the other hand, there may be additional opportunities where Government-industry cooperative investigation will be helpful. MCA presently has one such activity in working with the Division of Air Pollution of the Public Health Service in gathering data on atmospheric emissions from selected chemical manufacturing processes. This project operates under a formal memorandum of understanding, with each party defraying the expenses of its respective part in the effort. I have here a copy of one of the early reports from this study which is available to the public generally. (Copy provided may be found in the committee files.)

In this brief statement I have given some indication of our philosophy of approach to environmental controls and our general feeling about the status of technology now available to cope with current problems, including also some illustrations of the chemical industry's stewardship. In doing so, we have sought to relate these views to some of the salient issues raised in the report by your Research Management Advisory Panel.

Let me assure you that we are in full concord with a studied determination to recover and maintain air, water, and soil resources so that they will be of such quality to serve appropriately for the health, recreational, and industrial needs of the Nation. A formal declaration of this attitude, titled "The Chemical Industry and Environmental Health," was made by our association's board of directors on September 15, 1965, a copy of which is appended to this statement.

Because of the almost unending diversity of the chemical industry, I have not attempted to cover any particular technical aspects of chemical industry involvement. It seemed that the available time might be better served by leaving this to your questioning.

But before questioning, I would like to sum up our thinking with the following three points:

First, in the short range, timewise, major problems of disposal and pollution control can be handled by broader application of present technology and its constantly evolving byproducts. Assistance in certain fundamental research areas such as testing techniques, toxicology and hazard techniques will be most useful to industries involved in pollution problems.

Second, longer range, we need to start now with a massive systems analysis attack on all factors related to waste disposal, leading to a cost-benefit definition of pollution as it applies to each set of circumstances.

Third, we must obviously apply present and newly developing technology to the specific problems defined by the systems analysis. In these efforts you will find the chemical industry ready, willing and able.

Thank you very much.

Mr. ROUSH. Thank you, Mr. Logan. Unless there is objection, the paper you referred to entitled "The Chemical Industry and Environmental Health," will be made a part of the record, and if you have copies of the various documents or pamphlets which you referred to, we will receive those for the files.

(The document referred to follows:)

THE CHEMICAL INDUSTRY AND ENVIRONMENTAL HEALTH

I. THE PROBLEM FACING OUR NATION; ITS SCOPE

Environmental health encompasses the total impact of the environment on man's health and well-being, relating both qualitatively and quantitatively to the effect of the environment on man and to the effect of man's activities on his environment.

Environment means more than soil, air and water; it includes everything in this world—plants and animals, raw materials, food, wastes, space for work and play, as well as other needs for all of man's activities. Man's well-being means more than bare subsistence needs, it includes man's general level of health, security, comfort, leisure time, recreation and prosperity.

Man's environment, while being the reservoir for all his material needs, must also serve as the acceptor for all his wastes. In many ways, however, the environment is hostile, for it is from the environment that two of the traditional

regulators of man's numbers, famine and pestilence, have arisen. Man has learned to control and subdue these hostile elements effectively, largely through vigilance and technological advances. His numbers are increasing. He is living longer. His standards of living are improving in direct relationship to his utilization of these advances.

In modifying his environment, man has made tremendous gains in his well-being, but these gains have been accompanied by some unfavorable aspects. While gains have vastly outweighed losses, there is still need to deal effectively with the residual unfavorable aspects and to strive for products and activities with a more favorable gain-to-loss ratio.

Continued real progress can be made by the best use of available technology to reduce or erase unfavorable factors, man-made or otherwise; and by constant efforts to attain greater knowledge, better understanding and improved means for still further improvements in environmental health.

Perfect environment and perfect well-being are not attainable though we strive toward continued improvement. We do what we can with what we have now.

The involvement of all society and the limitations of man's present capability create specific problems within the overall area of environmental health. Principal among these are:

Technical Problems—Despite our advanced science and technology, man does not know all the answers or even know all the questions to ask. Technical problems demand full use of present knowledge and continuing research toward extension of that knowledge.

Social Problems—Since every segment of our society is involved, both as it is affected by and as it affects environmental health, every segment feels its interests must receive full consideration in any solution. These interests are numerous, varied, diverse, overlapping, contradictory, and unequal. The reconcilation of these interests and acceptance of any step to improve conditions require a weighing and balancing of the gains and sacrifices.

Economic Problems—Increased costs of raw materials, productive capacity, manpower, talent, time, goods, services, and taxes enter into the price of gain in environmental health. Again, all of our society is involved, this time in economic roles as consumers or taxpayers. These added costs must be evaluated in the hnadling of each particular problem. A practical balance of gain with cost is critically important.

Organizational Problems—Steps to alleviate the environmental health problem will require action by all society. Specific actions must be taken by individuals and by groups, yet each must be an integral part of an effective and equitable total. A need thus exists for an accepted public policy which is based on and which encourages constructive action by individuals and groups. Furthermore, self-initiated action based on responsibilities accepted voluntarily by individuals and groups of our society has always been more effective than action imposed solely by regulation.

The chemical industry of the United States has direct identification with several aspects of the nation's environmental health problem as a contributor of materials and services favorable to man's well-being and because these materials and services also entail some concurrent unfavorable aspects. Industry must therefore assess and act in accord with its responsibilities.

II. THE CHEMICAL INDUSTRY'S RESPONSIBILITIES

The chemical industry's responsibilities in environmental health matters derive from the nature and use of its products, from its research and production activities, and from its role as a segment of the economy and society. Effective action requires a high level of individual and corporate responsibility, and a continuing effort:

1. To advance knowledge and increase competence to deal with these responsibilities within the total problem of environmental health.

2. To assure the fitness and appropriateness of its products in relation to man's environment by best use of present scientific knowledge and by continuing to improve fitness and appropriateness as growing knowledge permits.

3. To plan and carry out production operations so that they:

(*a*) conserve health and safety of all those employed in the production of chemicals;

(*b*) conserve environmental resources, particularly by controlling and limiting emission and disposal of industrial wastes.

4. To assure the fitness and appropriateness in the use of the industry's products by:

(*a*) research and study aimed at broader and deeper scientific knowledge of the handling, application, and ultimate fate of chemical products;

(*b*) education of those who sell, handle, and use chemical products by clear instruction in all aspects of handling, use, and disposal, recognizing the need for change with the accumulation of further knowledge.

5. To promote a high degree of intra-industry cooperation, beginning with the promotion of full and free interchange, within lawful limits, of information and technology pertinent to environmental health.

6. To promote cooperation with all other segments of society in mutual effort toward solution of the total problem of environmental health, by:

(*a*) offering knowledge and technology for application wherever it may apply to the problem;

(*b*) accepting leadership responsibility in those aspects and areas where the chemical industry's experience may be of value;

(*c*) encouraging action by others throughout society, particularly in industry;

(*d*) cooperating as may be appropriate in any study or action undertaken by others in the scientific community, in academic circles, in public agencies and elsewhere.

Adopted by the Board of Directors, Manufacturing Chemists' Association, Inc., September 15, 1964.

Mr. ROUSH. Mr. Brown?

Mr. BROWN. No questions.

Mr. DADDARIO. Mr. Mosher?

Mr. MOSHER. Thank you, Mr. Chairman.

Mr. Logan, on page 4 of your testimony you stated that although administrative convenience might be served by having uniform requirements on discharges, et cetera, this would be economically wasteful as a general policy.

Would you cite one or two practical examples that would illustrate this philosophy?

Mr. LOGAN. Yes, I think I can, Mr. Mosher.

From my own experience in our company, we operate a plant which manufactures certain products. There are about 15 similar plants in the country operated by 6 or 7 other companies.

A uniform set of standards applicable to the discharge from these plants would create a chaotic condition in the industry and in the supply picture, because the conditions under which discharges from these plants are made are so totally different, one from the other. This is the essence of what I am getting at.

So a specific standard applied across the industry might be less than desirable in one location, but force another location completely out of operation.

Mr. MOSHER. To go a little further, can you say why? Can you give some specific illustrations?

Mr. LOGAN. Yes. The specific problem I am relating this to is well known in the industry and governmental circles. We have a plant on the Holston River in Virginia. This, in effect, competes with plants on the Ohio and the Mississippi, for example.

Now, the problem of discharging 1 ton of waste on the North Fork of the Holston River is very substantially different than it is on the Mississippi or the Ohio. And in the one case, the requirements——

Mr. MOSHER. You mean because of the volume of water?

Mr. LOGAN. That is right. Therefore, in the one case a standard might require little or no effort on the part of one plant facility where

in another case it would be technically and economically impossible to comply, and hence that operation would be required to be shut down with consequent economic effect on the whole area.

Mr. MOSHER. Yet, from the public interest standpoint, it might be argued that it is important that the quality of the water in your river as compared to the Ohio River should be essentially the same.

Mr. LOGAN. Well, I think it is a matter of public interest, and I am perfectly willing to let the public decide. That is what we are saying. In the case of the operation on the Holston River, maybe the public would decide that it was in their interest to continue the operation of the plant. This is one of the complexities that I referred to that probably has to be subjected to a rather broad scale systems analysis to take into account factors other than mere discharge problems.

Mr. RYAN. Would the gentleman yield?

Mr. MOSHER. Yes.

Mr. RYAN. If each plant, wherever it was located, was required to apply the same methods to handle the pollution, why would there be a competitive disadvantage?

Mr. LOGAN. As a matter of fact, each plant is applying essentially the same disposal techniques today.

Mr. MOSHER. But the result is different.

Mr. RYAN. I understand that. But suppose you did not have the water in which to discharge it?

Mr. LOGAN. Based on the present status of technology and the economics associated therewith, the plant would shut down. This conclusion has been stated in hearing reports that have covered this subject over a number of years.

Mr. WILKENFELD. There are two points under consideration here, and I think it would be well if we recognize these. One is basing control on the quality requirement in the stream itself, and the other is basing control on effluent quality requirement, and this sometimes gets confused in discussions such as this.

If the water usage of the stream is such and the waterflow in the stream is such that they are comparable, then the quality requirements in the stream should be the same. I don't think anyone questions this. On the other hand, if the volume of water available to carry the discharges away and/or the usages of the stream differ, there is no reason why the discharge quality should have to be the same.

Now why put both companies on an equal economic footing? In a competitive economy no two plants are ever on the same footing. One has different wage scales; one has slightly different distribution costs; the cost of bringing in equipment may vary. All sorts of factors enter into it, including the differences in the processes themselves.

So I don't think we have every attempted in the United States to make sure everybody spends exactly the same amount of money to produce something, and I don't think any two producers ever do.

You will find that profit margins vary between companies and I find it hard to see why in pollution abatement everyone should suddenly pay the exact same amount of money for treatment. This means that everybody would have to be on the lowest possible basis of discharge to take into account the man on the smaller stream, and can only result in increases in costs beyond that that is required.

Mr. MOSHER. I doubt that many people would disagree with what you are saying, and yet certainly the ultimate quality of the water is what we are primarily interested in.

This may be a philosophical matter which the Congress may ultimately have to consider. You are probably saying that quality standards can be adjusted from stream to stream and one body of water to another, depending on the public interest in those particular streams and the uses to which those streams are to be put.

Mr. WILKENFELD. Mind you, there is one thing we have to recognize: There are certain minimum base-level quality requirements that all streams must meet. At least the industry feels this way, and I'm sure the public agencies do too. And this is the protection of health, the avoidance of obvious nuisances, the degradation of aesthetics severely. These things must be protected on all streams as a minimum. Then how far beyond that you want to go will depend on the best interest of the community, and in many cases should be decided by the people themselves as it has been in the past.

Mr. MOSHER. I think it would be impossible for the Federal Government to set a single standard for every stream because obviously the flow and the volume of water and the nature of the fields and foliage and everything else along the stream is an influencing factor.

Mr. DADDARIO. Mr. Ryan.

Mr. RYAN. The other factor which is incapable of control is what other plants are discharging along that stream. So why not attack the discharge itself and then we eliminate this other problem of determining the quality of the stream?

Mr. WILKENFELD. This is exactly the role of Government in determining what quality level should be maintained in the stream, assessing how much should be put in and how this should be parceled out among the various contributors; it is a very difficult question.

Mr. RYAN. And it could require an interstate system to do this?

Mr. WILKENFELD. It could, and this is why we think the systems approach should be considered here, because it is so complex and must weigh in so many different factors.

Mr. CONABLE. Mr. Logan, I would like to know if the problem of your industry isn't probably inorganic waste? Certainly the organic part of your waste is readily controllable, as organic waste generally is, but don't we have some very serious special problems of inorganic waste with respect to your industry in particular?

Mr. LOGAN. I think we have some problems of inorganic wastes, yes. The organic chemical part of the industry has grown at a much faster pace than the inorganic, and I think there are problems in the organic area.

We have had the detergent problem, and basically the detergent problem was related to organic compounds.

I will defer to one of my technical experts to make a comparison, but I feel there are problems in both areas of the industry, Mr. Conable.

Mr. CONABLE. Are we making any progress in the inorganic field? A lot of the testimony here before this committee has been to the effect that it is possible to control the disposal of human waste by tertiary means. But have there been successful attempts to eliminate the inorganic chemicals, the phosphates, and so forth?

Mr. LOGAN. Let me answer your question about progress in the inorganic area, with two examples. I referred earlier to the problem on the river in Virginia. This has been substantially minimized by additional impounding facilities, by additional control of waste in the plant and by improved discharge of waste in relation to stream conditions. This has resulted in substantial improvement in terms of the waste content of the water.

In regard to air pollution, this report that the Public Health Service and MCA jointly developed is a survey of operating techniques in sulfuric acid plants.

Sulfuric acid is the largest inorganic chemical produced today, that is, the largest in terms of tonnage. It is the bellwether of the industry; it is an indicator of general economic and industrial activity.

Now, this report shows that various types of operations, indeed particular plants, are attaining certain results with regard to the discharge of sulfur oxides into the atmosphere. This information is already known now by every operator of a plant, and I can only presume that each and every operator is now attempting to solve his own problems in terms of the information that has been made available as a result of this study. To the extent that it can be accomplished, this may represent substantial improvement in any particular case, in regard to air pollution control.

Mr. WILKENFELD. May I interject this point? This whole matter of in-process control is a very important one in pollution abatement. To get back to differentiation between inorganic and organic wastes from industrial operations, there was a tendency to slide over organic waste disposal for industrial operations because this is the same as other secondary and tertiary treatments. This isn't necessarily so because industrial organic materials can be handled in many ways.

In many organic processes, you may be able to correct the problem in many cases by going back into the process as you cannot do in domestic sewage; changes can be made to reduce quite considerably the amount of material that is discharged, and this has been done in many cases; and a large share of the funds spent by the chemical industry has been for this type of control. In many instances it isn't necessary to install secondary treatment to further reduce organic wastes because of the considerable reduction made over the years in in-house modifications.

To be specific——

Mr. CONABLE. This makes it difficult to pin down your statistics, doesn't it?

Mr. WILKENFELD. That is right, it is very difficult to decide where to draw the line on what is an expenditure for pollution control.

Mr. CONABLE. And what is a salvage operation?

Mr. WILKENFELD. Yes; but this is the best type of control if you never generate a waste, but this has to be recognized as a legitimate method of control.

Mr. LOGAN. I think the economic pressures of competition are forcing constantly what we call in the industry tight systems, closed cycles.

Now, this is practiced to a much greater degree in the organic business. You are generally working with higher unit value materials