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## RESEARCH ON THE COMPLEXITY OF H<sub>2</sub>O

By

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It is truly a privilege and an honor to be here on behalf of the Naval Research Advisory Committee and to help in some small way in encouraging those of the expanded group who will work in the new building. It is my understanding that a talk at this time should be in the nature of an appetizer, since there is plenty of meat in the program proper.

Admiral Smith has told you that the Naval Research Advisory Committee is a statutory committee set up by Congress. To the best of my knowledge, the advisory committee to the Atomic Energy Commission is the only other scientific advisory committee of that distinction. You might ask, "What does such a committee do? How does it function?"

To start with, I would point out that it is supposed to consist of people who have had wide experience and who are recognized for their achievements and wisdom. For example, in the past the NRAC has comprised men such as Warren Weaver, Lee DuBridge, Louis DeFlorez, Lewis Strauss, and J. Robert Oppenheimer. Obviously this sounds like an important part of any roster of great living American scientists. Today the Committee comprises men of no less distinction, witness Drs. Rabi, Kelly, Stratton, Hunsaker, and Hutcheson, to mention just a few.

Obviously people of this type, having other responsibilities, cannot devote large numbers of days or weeks to detailed study of Navy projects. Their function is primarily advisory, to help set policy, and this they have done most effectively.

One of the more important aspects of policy is the maintenance of balance between development and research. As all of you know, research is one of those loose terms not well defined. Everyone has a different idea of research. To one man it is getting numbers from dynamometers. To another it is working out the solution of a differential equation. To still another it is synthesis for a new material of construction. There is no sharp line between research and develop-



ment, but human nature puts emphasis, effort, and money on those things that look immediate. Consequently, unless there is a conscious check and balance, development will always get an undue proportion of the effort and funds. The NRAC has realized the dangers involved in such a situation and has strongly expressed itself, with a resultant positive action by the Secretaries to maintain the basic research program.

The NRAC has also helped to open great bottlenecks. Presumably there is a much quoted law in the State of Kansas to the effect that, when two trains meet at a crossing, each train shall stop and neither shall proceed until the other has crossed the crossing. Unfortunately, we find a parallel in a great many situations, including some in Government research and development. One of the functions of the NRAC is to flag ahead one of the trains and unblock the situation.

For example, just before the National Science Foundation was first formed, the Office of Naval Research had increased war-time support of research in our universities in broad areas. When the Science Foundation was formed it might have seemed feasible for the ONR to drop support of all basic research except that which pertained directly to naval matters and let the Science Foundation carry on. However, the Science Foundation was a beautiful train on a track with no steam and no fuel for the boilers. At that time Congress had not appropriated much fuel. Rather than let the research stop, on advice of the NRAC the support of university basic work was continued by the ONR in areas that were perhaps somewhat less directly connected with the interests of the Navy. Incidentally, it is very difficult to ascertain just what field of basic research is not connected with naval warfare.

And now to my subject. I trust that the title has not deceived any of you. Obviously, if you talk about the complexities of  $H_2O$ , and research thereon, one first thinks of ionic bonds, covalent bonds, large molecules, surface tension perhaps, fluidity, viscosity under various conditions, vapor pressure, and the like. As I said, this talk is supposed to be an appetizer and not the meat. Any narrow conception of the problem of the complexity of  $H_2O$ , such as I have just indicated, could not possibly be covered in a half-hour talk. You must have much, much more time to get into this sort of detail. In a short talk such as this, it is necessary to have a broad subject so that the talk can be confined to generalities. Of course, sometimes it isn't confined to generalities. It may even include platitudes. I will try to avoid these.

We heard last night that some 75% of the surface of our planet is covered with water,  $H_2O$ . Physical research, in general, deals with



the relation of mankind to his environment and seeks knowledge of that environment for the benefit of mankind. Yet only a small percentage of the research that has been carried on in the last 20 decades has dealt with that 75% of our environment. So it is fitting that research on that environment be stimulated.

It is also true, as stated last night, that military demands and the impetus of war have been a terrific stimulant in scientific advances and invention. Psychologically it seems that if you have to do something to save your life, you do it, and quickly. If you have to do something just to live a little better, or if you do it for the sake of knowledge itself, time does not press and things move more slowly. But it is also true that, while many advances have resulted from military necessity or requirement, the great net benefit has been to our daily peace-time living. That is true of some things immediately connected with war, for example, dynamite. Actually, more dynamite is used now than was ever used in any war, and it is used for peaceful purposes.

Although the objective seems to be weapons of destruction and advances for the purpose of destruction, when we add it all up we find that it is the passing phase and that the real result and the real advance has made for better living.

I am sure you remember VanLoon's *Geography of The World*. He pointed out that on this planet the amount of space occupied by people is really quite small. The census states that there are about two billion people in the world; an easy calculation would show that the whole lot of them, theoretically at least, can be stacked in a cube a half mile on edge. This leaves a lot of "lebensraum" for anybody not in the box. If you don't like three dimensions, you can use two dimensions. If you want to put all of them inside a fence, you can have a circular enclosure with a 20 mile radius, in which case each one would have a little more than ten square feet. That, of course, is not much lebensraum. But it is not much of the planet's area either.

However, man uses quite a bit of space for food production. Malthus is the fellow who started this type of thinking. He had it all figured out that the human race couldn't possibly go on increasing for very many years because there wouldn't be enough space to grow enough food. Since then, by virtue of scientific advances, we have moved the decimal point on Malthus' calculations over so far that he begins to look a bit silly. On the other hand, there is a limit.

Even with a population of two billion we must go on, because it seems to be inherent in the mores of all cultures that the species must



propagate and must increase in order to have satisfaction. So we go on, and the population grows.

But how about the limit? The limit may or may not be food, as Malthus has predicted. We may run into other limitations. But consider food for the minute. Calculations have been made on food productivity from all of the land areas. As Admiral Smith has just pointed out, the sea is a major and wonderful potential source of food. I am not thinking now of the normal ways of winning foods from the sea, namely, catching fish, but rather what we might do, perhaps decades hence, with sea vegetation and the like.

In this connection one never knows how research in one area may provide a breakthrough in another.

The jet engine is rather recent. I doubt that many people have realized that the jet engine was made possible by research on the air compressor—on the turbine also—but primarily the compressor. And it is the improvement in the efficiency and effectiveness of the air compressor that has made the engine what it is today.

By the same token, pumps have not changed in character for many, many a year, decades, eons perhaps. You may say, "Well, the centrifugal pump, the rotary pump, is something new." Yes, it is relatively new. But just as research has resulted in a complete change in the mode of pumping air, so may we expect some development for moving water. I don't know what it is. If I did I would be hustling down to the Patent Office instead of standing here. But we may expect something in the way of developing pumps and moving water which would change the whole approach to handling the contents of the sea. When, is another story. We may even be smart enough to let that great pump, the moon, do the job for us. That pump, with its two strokes a day, really pumps a lot of water. Maybe we can do something about it.

There is a filtration problem, a precipitation problem, etc., but none of this scares anyone in industrial chemistry today. The energy to move the water and the modes of so doing are the things of concern. Once having done this, we have at our disposal a vast farm and a vast mine.

True, we are already taking magnesium out of sea water, also bromine, but pumping sea water for the salt isn't worthwhile. It is better to take more concentrated brines from below the surface of the earth only because it is too difficult to pump the water; it takes too much energy. Some day we will have atomic energy, economically. When it is economical enough perhaps we can use that to help pump water. Thus from atomic energy we will be getting food in an indirect fashion.

To conclude, we have a relatively untouched 75% of our environment on which to draw in order to improve our standard of living in the future. This we should realize. We should start and continue the basic research so that we can take advantage of the situation when the time comes.