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SCIENCE, TECHNOLOGY AND PUBLIC POLICY

By Dr. LYMAN CHALKLEY

OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

FOR some years the world has been engaged in the most destructive war of history. This has been the most destructive war because it has been the most "scientific" war. The sciences have been mobilized, and, through their expressions in technology, have been applied to destruction. The devastating results have been of a magnitude and worldwide distribution utterly beyond the reach of even the most bloodthirsty militarists of former ages.

Thus, in destruction, as in its more constructive applications to medicine, industry and the comforts and conveniences of living, the scientific method has shown itself more efficient and more powerful than any other approach to the solution of practical problems which mankind has devised. In spite of this generally accepted fact, no adequate machinery for bringing our public policy into harmony with the development of science and technology has been set up.

There are many evidences of this situation. As early in the war as April, 1942, *Fortune* magazine pointed out that, although this was a scientific war, neither scientists nor technologists were members of the top military or civil policy-making groups. This is still true. The Dumbarton Oaks Plan, while recommending an Economic and Social Council, entirely ignored science and technology. The San Francisco United Nations Conference has done likewise. Yet no field of human activity is to-day a greater factor in the war-making potential of nations.

Another problem growing out of the war is the postwar control of Germany. In a letter of Sep-

tember 29, 1944, to the Foreign Economic Administration, President Roosevelt wrote:

Control of the War-Making Power of Germany. You have been making studies from the economic standpoint of what should be done after the surrender of Germany to control its power and capacity to make war in the future. This work must be accelerated, and under the guidance of the Department of State you should furnish assistance by making available specialists to work with the military authorities, the foreign service and such other American agencies and officials as participate with the United Nations in seeing to it that Germany does not become a menace again to succeeding generations.

On this subject numerous studies of various economic and industrial phases of the problem had already been made. The Brookings Institution had published a report on "The Control of Germany and Japan." Among other books on the same subject may be mentioned "The Problem of Germany," by the Royal Institute of International Affairs; "How to Treat the Germans," by Emil Ludwig; "How to End the German Menace, a Political Proposal by Five Hollanders," and "What to do with Germany," by T. H. Minshall.

Yet there seem to have been no studies of the scientific factors involved. The control of research is an idea foreign to our thinking; we have striven, and successfully, to encourage research. The direction of the output of the laboratories to socially desirable ends has never been a problem to us because we have looked upon science as a purely beneficient agency. Now the war has come along and taught us that science and technology can be the source of the most destructive forces the world has ever known.

Our thinking has not caught up with this appalling fact. There are no Brookings Institutions to study the relations of science and technology to our economic, political and social structures. The best that the Foreign Economic Administration could have done on the scientific phases of the assignment contained in the President's letter of September 29, 1944, would be to turn to a temporary wartime government scientific agency (since there are no permanent ones) for aid. It in turn could only enlist the advice of a group of competent men meeting as a committee in Washington or New York. The recommendations resulting from such a procedure are the best that could be obtained with our present machinery, but they are not the best that should be had.

However competent the advice and however well informed and wise the advisers, more than advice is needed for a new problem of this sort. The best of advisers are the first to base their advice upon a background of factual information as to conditions and relationships in the field in which they are advising. But adequate information cannot be gathered over night. Its accumulation generally requires a long period of painstaking study. In various economic fields we have a background of many factual studies, but in the field of what might be called "science policy" we have virtually none.

Yet the control of German science, so that it can not become the physical basis for another war, is such an important matter to our nation, not only for the present moment but for a generation to come, that it is deserving of thorough and sustained study, for which there is no agency at the present time.

The problems of war are not the only ones in which science and technology are important factors in public policy. On November 17, 1944, President Roosevelt in a letter to Dr. Bush, the director of the Office of Scientific Research and Development, asked for advice upon:

First: What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?

The diffusion of such knowledge should help us stimulate new enterprises, provide jobs for our returning servicemen and other workers, and make possible great strides for the improvement of the national well-being.

Second: With particular reference to the war of science against disease, what can be done now to organize a program for continuing in the future the work which has been done in medicine and related sciences?

The fact that the annual deaths in this country from one or two diseases alone are far in excess of the total number of lives lost by us in battle during this war should make us conscious of the duty we owe future generations.

Third: What can the Government do now and in the future to aid research activities by public and private organizations? The proper roles of public and of private research, and their interrelation, should be carefully considered.

Fourth: Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?

In turn Dr. Bush appointed very able and conscientious committees to consider these matters and to advise him on the recommendations he should make to the President. These committees had a background of information to draw upon. The National Resources Planning Board, and its predecessor, had already issued reports on "Industrial Research" and on the "Relation of the Federal Government to Research." There had also been hearings on the patent system by the Temporary National Economic Committee, and still later there were numerous hearings on the war use of science and technology before Sen-

ator Kilgore's Subcommittee on War Mobilization of the Senate Military Affairs Committee.

However, the peacetime questions raised by the President are not only important but continuing, and they may be expected to grow in importance in the future. Certainly they cannot be answered at one time, once and for all, by ad hoc committees which go out of existence when their reports have been written, or even by a temporary wartime government agency whose life is also limited.

The perpetuation of the Office of Scientific Research and Development after the war might seem to meet the need for continuity in the study of the relation of science to public policy. Certainly a permanent government scientific agency is needed. However, some matters in the relation of science to public policy are too broad and too important to the welfare of the American people to be entrusted solely to any administrative agency.

For example, the scientific rearming of Germany in preparation for the war was well known to American scientists and this information was available to the Federal Government. Yet the government took no action until after the fall of France to prepare for its own scientific rearmament. The Army and Navy appropriations for research had been pared to the bone, and this paring seems to have been done by the Administration itself. For in a hearing before the Select Committee of the House on Post-War Military Policy, Representative Snyder stated in speaking to Colonel Osborne, who was testifying for the Army Service Forces:

> Since I have been chairman of one of the Appropriations Committees, which has been for 7 years, we have never turned down a single cent that has been asked by the Army for research and development. So, if they do not have enough money for research and development, it is not the fault of Congress or it is not the fault of my committee. It would be the fault of somebody downtown.
>
> I do not know whether it is the Bureau of the Budget or whether it would be the Army agencies that have looked after that. But it is not the fault of my committee or the fault of Congress as a whole, if you do not have money for research and development, because you got everything you asked for, or you have at least for the last 7 years.

Later in the same hearings Representative Mott in questioning Dr. Jewett, president of the National Academy of Sciences, said:

> In my recollection, the Congress has never refused to appropriate for research, and never refused to appropriate for an educational order, whenever they were asked, but the history of it is that the Services were not allowed to ask the Congress for the money. The Budget either eliminated it or cut it down, and these necessary research activities which we know were very necessary, never even came to the Congress. They had a rigid restriction under the present set-up as to what an agency of the Government, what the Army or the Navy might ask Congress for. If they put in an estimate to the Budget and the Budget said, "You don't need that," they were precluded by Executive Order from even saying anything about it to the Congress. That is one thing I think ought to be corrected.

Clearly there was no agency concerned with scientific policy in these crucial years before the war to study, and to make generally known, Germany's scientific preparation for war, and the organization of our own government for scientific preparedness. The lack of adequate scientific representation and advice in the councils of the Army, the Navy and the Bureau of the Budget in the critical years before the war, if such were indeed the case, could have been disclosed only by a non-governmental source. Even the National Academy of Sciences could hardly have made such a report because of its quasi-governmental position.

The scientific preparedness of the country after the present war is of paramount importance to our future welfare. This point was stressed by the director of the Office of Scientific Research and Development who, in his testimony before the House Select Committee on Post-War Military Policy, said:

> The great change in pace which science and technology have introduced into warfare underlines the vital importance of continuing an effective research on military problems in time of peace. In the past, the pace of war has been sufficiently slow so that this nation has never had to pay the full price of defeat for its lack of preparedness. Twice we have just gotten by because we were given time to prepare while others fought. This time the margin was narrower than in 1914. The next time—and we must keep that eventuality in mind—we are not likely to be so fortunate.
>
> The speed and surprise with which great damage could be done to our fleet at Pearl Harbor is only a mild warning of what might happen in the future. The new German bombs and rocket bombs, our own B-29, and the many electronic devices now in use which were unknown 5 years ago, are merely the forerunners of weapons which might possess overwhelming power, the ability to strike suddenly, without warning, and without any adequate means of protection or retaliation. I do not mean that some methods of protection or retaliation could not be developed. I only mean that we might not be given sufficient time within which to develop these means, once hostilities had begun, before disaster overtook us.

The public should be kept informed on the progress and state of this preparedness, not just now, when there is little danger of another world war, but for years in the future.

The continuing study of the proper place of science and technology in our national life and in the world

is a project similar to those which are undertaken by the Brookings Institution, the National Industrial Conference Board, the 20th Century Fund, the Russell Sage Foundation, the Foreign Policy Association and other organizations in various fields of social and political economy. While there are foundations devoted to such thoroughly worthy objects as the promotion of good government in Philadelphia and the promotion of Henry George's writings and ideas, there is none devoted to the equally worthy studies which may be necessary to keep us from being exterminated by bombs or germs sent us from abroad, or to help us to avoid exterminating ourselves through the misuse of powers whose effects we do not yet fully understand.

It might seem that the study of the economic and social relationships of science and technology could be undertaken as a project of one of the economic research organizations or of the scientific research organizations, such as the Carnegie Institution, The Franklin Institute or the California Institute of Technology.

There is probably no basic reason why either the economic or physical science institutions should not undertake such studies. But there is the important empirical fact that a gap exists between the economists and the natural scientists in methods of thinking, approach to problems and in their contacts with each other. It might require very considerable changes in the existing research organizations to equip any one of them for studies of the place of science in our economy.

However, the gap between the natural and social scientists is narrowing. Even well before the war the Massachusetts Institute of Technology included in its curriculum studies of economics, management and industrial relationships along with the technological courses. During the war Dr. Bush and his Office of Scientific Research and Development have made great strides in bringing scientific viewpoints into the war councils not only of the military but of the civilian agencies of the government as well.

The time may be approaching when a rational and sustained attack upon the problems which science and technology have introduced into the life of the nation and of the world will not only be possible but may even seem sufficiently interesting and imposing to stimulate a major study of these things. Let us hope so, for our future security and welfare may depend upon it.

SURFACES OF SOLIDS IN SCIENCE AND INDUSTRY. II

By Professor WILLIAM DRAPER HARKINS
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(*Continued from page 268*)

III. The Area Occupied by Molecules

It is now possible to calculate the area occupied by a molecule. It has been customary to measure the area (Σ) of a solid by assuming an area (σ) for the molecule and multiplying this by the number (N) of molecules in a complete monolayer. Since our new method makes it possible to obtain the area of a solid without assuming a molecular area, and the BET theory makes it possible to calculate N, the area per molecule is given by

$$\sigma = \Sigma/N$$

The extremely interesting plot (Fig. 10) results when the number (N) of solids, on which the nitrogen molecule exhibits a certain area, is plotted on the y-axis and the molecular area (σ) on the x-axis. The minimum molecular area found on 119 solids is 13.45 square A and the maximum, 17.05 square A, with peaks at 14.05, 15.25 and 16.25. Thus, the areas of nitrogen molecules vary from about that calculated from the volume relations of solid nitrogen to that obtained from liquid nitrogen.

That these areas correspond to real effects is indicated by the following interesting facts:

1. The nitrogen area on a catalyst may have *any of the above values,* but this shifts to 16.2 square A

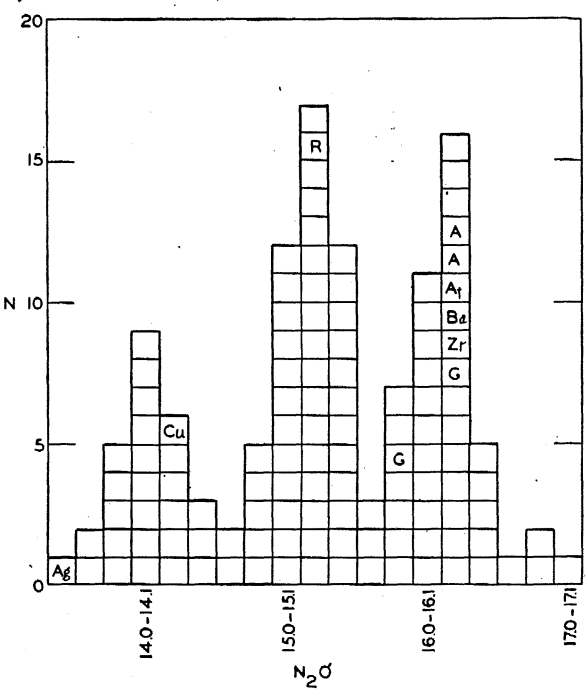

FIG. 10. Areas occupied by nitrogen molecules in complete monolayers on various solids.