SCIENCE AND INDUSTRY IN NATIONAL SECURITY*

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THERE is a great voice in the world to-day, the voice of science and technology. It is a voice heard since ancient times but never until to-day has it spoken with such authority, have its words been so filled with promise, has it been listened to with such hope; and in no country in the world does the voice speak so eloquently as in the United States.

Science and technology have changed and are changing the lives of all men. Not a single aspect of our society but feels their advance. The things we make and use, the food we eat, the clothes we wear, the way we travel and communicate, the houses we build, the way we cure and prevent disease, the way we fight—and the way we shall win—have all been fashioned by science. Both war and peace move under the sign of research, discovery and invention.

While our thoughts and energies must still be devoted without stint or limit to the task of defeating Germany and Japan, second place in our thought and planning should be directed to the problems of the future. How shall we repair the ravages of war? How shall we create a society in which full production and full employment can be maintained? How shall we promote and maintain the security of the United States—and thereby contribute to the peace of the world—so that no aggressor will dare again to jeopardize our status as a free people. It is on the last question, on the part which science in industry can play by developing our resources, and advancing our technology in the interest of national security that I would speak.

I conceive the term national security to embrace a wider field than the maintenance of an adequate army, along with the development of powerful and effective weapons; because, in working on the normal products of peace, we at the same time make an essential contribution to our military strength. First, then let me briefly consider national security in its wider sense.

It is to the interest of all that America's scientific men engaged upon both pure and applied research should turn our swords into ploughshares as successfully as they have turned our ploughshares into swords. We shall need the development of new aeroplanes and helicopters, light metals and plastics, television and radio, new foods and medicines as much as we have needed and still need combat aircraft and jet propulsion, heavy armour and new explosives, radar and 'walkie-talkies', high-calorie rations, penicillin and blood plasma. I do not doubt that after victory we shall need the products of peace even more, for ours is not an aggressor country with imperialistic aims; the ideals of our nationalism are the ideals of peace and security.

To get the most out of all science, whether devoted to peace or war, there are certain things to be kept in mind. For one thing, research and development in industry, as in the university, flourish best in an atmosphere of complete freedom; control will wither science by destroying its precious essence of originality and spontaneity. If I were to add to the four

freedoms of the Atlantic Charter, I might suggest a fifth—freedom of inquiry, experiment and research.

With that principle in the forefront of our thought, I think we must concede that in view of its position in the modern industrial State, in view of the way science is woven into the cloth of our society, it cannot be left unorganized and unsupported save by sporadic benefactions. A few of the great industries of the United States have been able to establish magnificent laboratories, and the discoveries and inventions flowing from them in a ceaseless stream have enriched our lives in peace and contributed heavily to our ultimate victory in this War. The laboratories of the universities of the United States, especially in the field of pure science, have steadily broadened and deepened the foundations on which all applied science must rest. The laboratories of the Federal Government, in the fields of agriculture, public health, medicine, meteorology and the development of the tools of war have also made an enviable record.

Essential as these contributions have been, we cannot afford to look exclusively to the laboratories and workshops of our major industries, universities and the Federal Government. While important scientific advances are not often made in attic, cellar or barn, as was the case not so long ago, we must not permit the precious stream of discovery flowing from smaller industry and smaller educational institutions to be dammed up by neglect. Small business needs technical information; universities not possessed of vast endowments need help; scientific research and development are of national interest, and whether they be devoted to national defence, public health, public housing or to normal scientific activity for commercial purposes, they must be encouraged, and if they need help they must have it.

Dr. J. B. Conant in a recent address said that the future of the physical sciences depends on the "number of really first class men" that can be turned out by our educational institutions. He urged that talented young men and women be afforded unhampered opportunity for research in both industrial and university laboratories; he advocated Federal scholarships for high-school graduates of technological promise, thus creating what he called "a scientific reserve" for national security. Without considering the exact means required to assure educational opportunities for young men and women of scientific promise, I am in full agreement with Dr. Conant's view as to the need and urgency.

Certain aspects of research, apart from the development of weapons, must, it seems to me, continue to receive Federal support or be carried on by the Federal Government. Agriculture, public health and housing fall in those categories. Certain economic problems also are in need of the clear light of science. The Federal Government, with unique access to full statistical data on population, manufacturing, crops, markets, methods of distribution, is in a position to help shed that light.

Nothing I have said should be construed to mean that in any of these fields the activities of the Federal Government should preclude or foreclose the research and development of private industry or the universities. In normal research and development during peace, the larger share must be contributed by the citizens and not by their Government. That is compatible with the view that in certain types of research the Federal Government must serve the needs of

* Address at the Silver Anniversary Forum on "The Future of Industrial Research", arranged by the Standard Oil Development Company, on October 5.

science. It must act as a stimulating force, it must furnish scientific information, it must lend financial support if it be needed.

In many scientific inquiries there is room for a co-ordination of effort. If it be deemed wise, the Federal Government might be called upon to participate in that function. There is urgent need for the fullest possible exchange of information between scientific workers in industry, academic centres and the Federal Government. How to achieve that co-ordination and a free exchange of data is a basic problem which has not been thought out to a satisfactory conclusion, although much work has been done upon it.

If I may sum up, the job of normal peace-time research is a private job, not a government job. Those branches in which the Government will continue in the principal role are well known; in no way do they conflict with the scientific functions of industry or university. What the Government may do, if it is called upon, is to furnish information and financial support. It may offer counsel, even leadership. It must not, in the normal researches of peace, assume control.

Up to this point I have been talking largely of scientific and technological research which, though of major importance in the national interest, will go on with or without any further plans we may make. But their advance will be facilitated if the factors to which I have briefly alluded are recognized and met.

Research and development devoted to the weapons, tools and techniques of war present us with a tougher problem. Such research will not go on to the extent required for our national security unless support, guidance, even control emanate from central mechanisms.

In time of war, when the nation's existence is in danger, no body of men responds more generously, with greater energy and zeal to the needs of their country than scientific men and technicians. That was our experience in the War of 1914-18; it is also our experience to-day. Industries and universities have turned their laboratories inside out to give their country what it needed, whether they were summoned or not. Men and women who people those laboratories have given us more than we dared hope for. Thousands of lives of our fighting men have been spared, most of the wounded restored to health. Our troops have been equipped with weapons equalling or surpassing those of the enemy; final victory has been brought immeasurably closer, as a result of the efforts of scientific men and technicians.

With all our grumbling, good-natured or otherwise, the fact is that on the home front in the United States we have scarcely felt the War, and that too is in large part to be ascribed to the efforts of our scientific workers.

But when peace comes, ours being a peace-minded nation, we shall have the greatest difficulty in keeping even a small portion of our best scientific brains on the job of maintaining the weapons of our Armed Forces at the high peak of effectiveness they now occupy; unless a suitable programme is evolved to draw and hold scientific men of the highest level, they will not be available for Government service in peace-time to supply the Armed Forces with the best science has to offer. They will return, as is only natural, to the industrial laboratories and the universities they came from. Nor will it be possible in the Government laboratories that will be continued in peace to carry through all the research in ordnance,

aviation, radar, rockets and new weapons, in the many specialized nutritional, physiological and other fields which underlie the waging of modern total war. The research facilities and the scientific man-power prerequisite to these activities will simply not be available to the Government in sufficient degree. No acts of Congress or of the executive branch of our Federal Government can alone meet this deficiency. At almost every point of maintaining the technological strength of our Armed Services—whatever mechanism we devise to achieve this end—we shall have to turn to the research laboratories and the research workers of industry and the universities to fulfil our needs.

To some extent, as I mentioned at the outset, our task is made easier—paradoxically, I may say—because modern war is total war. In other words, much of the research carried on by industry and universities to meet the needs of peace will meet the needs of war if this tragedy should be thrust upon us again. In the field of chemicals, rubber, synthetic oil fuel, electrical instruments, engineering products, medicines, light and heavy metals, and food products, research for peace is research for national security. Also in the case of certain end products of purely military use, the intermediary products may be suitable for civilian consumption.

Research and development in connexion with most weapons are in a unique category. A host of factors stand as obstacles where the help of industry and the universities is concerned. Among these are the specialized tools and machinery required, the extensive proving grounds and test plants, the heavy expense, considerations of secrecy, the tenuous and inadequate liaison, during peace, between private industry and the Armed Services, the indifference or hostility of public opinion towards the development of war weapons in times of peace, the competing demands for commercial products.

Aware of the gravity of this problem and anxious to find at least a partial solution, some of the leading men of the National Academy of Sciences, the National Research Council, the Office of Scientific Research and Development and members of the Armed Services engaged upon research and development, have for some time past been weighing the merits of alternative plans for an organization which in the post-war world will deal with military scientific research and attempt to assure to the Armed Services the scientific help and interest required of industry and the universities. I would like to mention briefly some of the questions which this group has had before it, because I believe that these questions are in almost all respects similar to those which industry must answer in developing its policies for research and development pointed towards national security.

The first question is how shall we obtain for the Federal Government the full-time or consulting services of scientific men on the highest level.

It has been suggested that we need an agency, with distinguished leadership, such as we now have in the Office of Scientific Research and Development, and with ample funds, to promote precisely those branches of research and development which will effectively contribute to our military strength. For this is the type of research which if left unattended and unsupported cannot flourish. Between the War of 1914-18 and this War the funds made available for research and development in the military sphere were wholly inadequate. They are adequate now, but they must be kept so. The adequacy of Federal

appropriations to promote military research will determine, in large measure, the contribution that can be asked of private enterprise in terms of personnel and laboratory facilities. While the arguments for the creation of the new agency are impressive, I do not believe that such an agency would fully solve our problem. For the problem is essentially one of men and women, not of organizations. We must have sincere and spontaneous interest in research aiming at national security, and this does not grow out of organizations and subsidies alone, however important these may be.

An important obstacle in enlisting the aid of industry is the difficulty of liaison and interchange between the military services and industry. How can we best meet that problem, recognizing that there is one sphere fully and properly under military control, another fully and properly under private control, but there is a large area of both spheres common to both? It is manifest that if industry's help in weapon development is needed, so far as the work requires, the military must take industry into their confidence, and vice versa. There must be an avenue between industry, university laboratories, government laboratories, and the Armed Services, and there must be no one-way signs upon it. How can we best achieve this end, not theoretically, but in day-to-day work?

How shall extensive work in weapon development be financed? To this there is no simple answer. No industry, however large, can be expected without government subsidy to undertake elaborate research for the weapons of war, especially the accelerated and ceaseless research peculiarly required in this field. How shall this subsidy be administered? What is its probable magnitude over the next ten or twenty years?

Financing by way of subsidy or contract payments will, I recognize, often not be enough. We shall need other forms of incentive, financial in character or otherwise. Over and above that, we shall need the approval, the sympathy, the leadership from civilian as well as military circles to enlist public opinion in support of a sound programme.

I know that the exchange of patents and licences in connexion with research on military products is many-sided and troublesome. I mention it also because of its particular concern to industry. I believe, however, that a solution for that question will not be difficult to find, once a basic framework for the entire research and development programme in the post-war world is erected.

What research facilities can and should the Government provide for industry and universities in the United States? We cannot expect that the research facilities of the Federal Government will be increased after the War ends. We cannot expect, on the other hand, that even the largest industries will be able to provide the proving grounds and more especially the test plants, so that we can convert the successful solution of laboratory problems to successful solutions in production. Proving grounds will doubtless be made available to industry. What of pilot plants? These questions are, of course, intimately related with the problem as to what research functions in the development of weapons the Federal Government itself ought to continue to perform.

Planning for the results of science is unwise, for results cannot be anticipated. But we must not forgo plans for research, suggestions in definite fields in which valuable results may reasonably be anticipated.

My friends who are scientific workers tell me that so rich and limitless, so untapped are the possibilities of science that the discipline of planning consists as much in saying what roads ought *not* to be followed as what roads ought to be. At every stage of developing our research on weapons we must have a standard of values, so that although research would not be confined, lesser problems would be subordinated to questions of vital national need. That standard of values must be keyed to the current strategic thoughts of our military leaders and must be accessible to the leaders of research. If the link fails in either respect, we cannot expect to gain the full benefit of our vast research machinery. Repeatedly this War has shown that science leads tactics; this will be fully as true in wars of the future. We will make our plans to suit our weapons, rather than our weapons to suit our plans.

The U.S. War Department has grown increasingly aware of the need for research and development in connexion with new weapons. In partial response to that need there was created within the War Department, more than a year ago, the New Developments Division. This Division is charged with functions relating to the initiation and co-ordination of research and development and the expeditious application of new weapons, devices and techniques. It has proved its usefulness, and will, I hope, continue to do so in increasing measure. Its working relationship with the two scientific agencies to which we all owe so much, the National Research Council and the Office of Scientific Research and Development, has at all times been close and effective. I realize that this Division marks only the beginning of the road to our goal. For in every one of its activities, after the War as now, the War Department must train its men, shape its plans and its actions so as to reflect the most recent advances of science. It must not lose sight of the fact that significant discoveries and inventions are usually the matured products of years of thought and experiment, with innumerable disappointments and failures along the way.

In my judgment a single unified defence agency combining the Army and Navy would go far towards solving many of the problems to which I have referred. The establishment of a corps of scientifically trained officers, for which persuasive arguments have been offered, is only one step of many which the creation of a unified defence agency would facilitate. It is a step which merits serious attention, whether or not a peace-time scientific agency, of the kind I mentioned before, is created. It envisages the training of a group of talented young scientific men, and others with professional skills, within the existing framework of the Armed Services, as an integral part of the U.S. Army and Navy. Members of this group would have their regular basic military training at the academies. Once their talents were demonstrated, they would be given full opportunity to keep pace with the advance of science by postgraduate work in universities and industry. They would be assigned to the research and development branches of the several services in accordance with proved ability. They would grow within the services, be acquainted with their problems and contribute not only in terms of professional skill, not only in propagating the views of science, but also in linking the scientific and technical activities in universities and industry with the parallel activities of the Armed Services. This is a concept that commends itself to our attention; it is one on which the U.S. War

Department is most anxious to hear the views and criticisms of industry.

I cannot leave these points without mentioning again the matter of science in education which I referred to before. The future does not belong to us. It belongs to our children and to their children. We must look to them for the future of science. Unless we give them the training, the opportunities, the facilities for turning their talents and their genius into a powerful and disciplined machine, we cannot envisage a bright future for science in America.

It is a heavy assignment of responsibility to say that the future of the United States in peace and in war is to a great extent in the hands of American men of science in industry, in schools, in universities and in government. But I believe the responsibility is properly assigned, and I have confidence it will be met. Vice-President Wallace once stated that science and technology, like good will, have no natural boundaries. The opportunities, the freedom, the security which science can give to our people can be extended to the corners of the earth. By so extending them industry will make its greatest contribution to national security. The perils of war give the precepts of peace. With the help of science and the men and women who make it we shall maintain that peace.

NATIONAL FLOUR (82½ PER CENT EXTRACTION) AND BREAD

Sixth Report from the Scientific Adviser's Division, Ministry of Food

ON October 1 last the extraction of National flour in Great Britain was reduced to 82½ per cent. This lowering of the extraction followed work which showed that the bulk of the vitamins and minerals in the wheat grain are located in the germ, particularly the scutellum fraction, and in the outer endosperm adjoining the bran. Provided these two fractions are included in the flour, there will be no appreciable difference in the nutritive value of 82½ per cent as compared with 85 per cent extraction flour. At the same time, the fall in the extraction makes it possible to exclude about 1.6 per cent of bran (on the average, 85 per cent flour contains 4 per cent bran) and so give a whiter flour and bread. Details of the milling technique necessary to produce a satisfactory 82½ per cent flour have been circulated to all millers¹.

Quality of Flour

Mills were allowed about a fortnight to settle down, after which each mill was instructed to send a 6-lb. sample once a week to the Cereals Research Station, St. Albans, for analyses. These covered colour, fibre, ash, added calcium, iron, vitamin B₁, riboflavin and nicotinic acid; in addition, the flours were examined for baking quality.

It was impossible to examine every sample in every respect each week. Thus, the 'colour' of every sample was judged each week; vitamin B₁ was determined on samples from all the larger mills every week, and on the remainder once in four weeks, thus covering more than 80 per cent of the total national flour production—on a capacity basis—every week; calcium (as added creta preparata) was determined fortnightly on all samples; fibre and ash were

determined on all samples sent by Ministry of Food inspectors, while the remainder of the mills were covered in about eight weeks; about forty flours were baked every week, thus covering all the mills in six or seven weeks. All mills included in the survey were grouped according to their capacity (five groups: up to 5, 6–10, 11–20, 21–50, and more than 50 sacks/hr.) and their port area (London, Bristol, Liverpool, Hull, Leith, Glasgow, and Northern Ireland). Aliquots of samples from all mills in the same capacity-group in each port area were bulked together to form a total of thirty compound samples upon which riboflavin, nicotinic acid and iron were determined fortnightly.

The production of a whitish flour of high nutritive value is a new development, and so the analytical results are given in some detail.

Colour Index. Colour (bran speck contamination) was judged on a scale of 0 to 100, where 0 represented a white flour free from visible bran specks, and 100 represented the national average 85 per cent flour (capacity basis) as manufactured during July–September, 1944.

The percentage of all samples examined that fell within the various colour index classes week by week is shown below. The average colour indexes on a mill basis and on a capacity basis are also shown.

Colour Index not exceeding	Week commencing	A	B	C	D	E	F	G
10	Oct. 16	23	30	Nov. 6	13	20	27	
20		5	8	12	19	15	11	15
30		15	21	29	36	29	30	30
40		27	34	42	49	50	48	50
50		46	49	54	66	54	61	62
60		59	65	69	75	68	77	79
70		76	80	79	87	80	85	89
80		85	87	88	91	92	91	94
90		89	92	92	92	93	94	96
100		91	94	94	96	96	97	98
Average Colour Index	Mill basis	59	55	53	47	49	49	47
No. of samples	Capacity basis	51	45	43	36	38	38	37
		226	226	237	246	248	247	254

Vitamin B₁. The percentage distribution of vitamin B₁ values and the weekly average vitamin B₁ value (mill basis) were as follows:

B₁ (I.U./gm.)	Week commencing	A	B	C	D	E	F	G
1.10 or more	Oct. 16	23	30	Nov. 6	13	20	27	
1.05 " "		2	0	0	0	0	1	0
1.00 " "		18	3	4	4	4	4	3
0.95 " "		38	17	20	11	20	13	11
0.90 " "		59	38	43	38	45	38	35
0.85 " "		79	65	62	53	68	65	53
0.80 " "		91	88	78	84	89	85	78
0.75 " "		97	96	90	94	97	95	86
0.70 " "		99	97	97	98	99	97	93
0.65 " "		100	98	99	100	99	98	96
0.60 " "			98	99		100	99	98
0.55 " "			100	100			100	99
No. of samples		99	118	112	117	112	119	130
Mean vitamin B₁ value		0.92	0.87	0.87	0.86	0.88	0.87	0.85
Per cent of the total milling capacity analysed		82	84	81	83	81	81	83

The average value for vitamin B₁ over weeks A to D (during which all mills were covered), on a capacity basis, was 0.88 I.U./gm.

Riboflavin, nicotinic acid and iron. The average values for these constituents (mill basis) are given in the following table:

	Fortnight commencing			Average for six weeks
	Oct. 16	Oct. 30	Nov. 13	
Riboflavin (µgm./gm.)	1.0	1.0	1.0	1.0
Nicotinic acid (µgm./gm.)	18	18	19	18
Iron (mgm./100 gm.)	1.99	1.99	1.84	1.94

Ash and fibre. The average ash and fibre determinations (mill basis) on samples sent by mill inspectors were as follows: