III

THE INFLUENCE OF SCIENCE ON HISTORY*

THIS is the last of the current series of lectures on "Recent Advances in Scientific Research." On behalf of the Rice Institute, may I express appreciation of your interest in them? The subject was selected as indicative of the interests and activity of a considerable fraction of the Rice faculty. We are all interested in recent advances, as concrete evidence of the living and growing nature of science. But even though the interests of men of science are in the more recent developments, and your interest is in the latest discoveries and inventions and their possible influence on your affairs, one may sometimes profitably look back to see the way in which science has influenced the activities and the thinking of people over the centuries. The influence of science on history is not always easy to identify, because the records themselves are not very complete, and we do not always read them with discernment. Frequently the most significant changes are those which because of their subtlety we fail to recognize at all.

There has recently been a great deal of discussion about freedom of science, and the freedom of scientists to carry on their work without external limitations of any kind. Science has been very largely free in its most productive years. Scientists have worked in the obscurity of university or private laboratories, and have all too frequently been accorded recognition only after death. It has sometimes been suggested

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that science has been free in the past, because it was felt to be of no importance; because it was believed to exercise a negligible influence on the current pressing affairs of the world. Or that, in any case, any influence it might exert would be too far in the future to be of much concern.

This feeling has very largely disappeared, and because of the spectacular way in which scientific work contributed to the activities of the recent war, there is a widespread recognition of it as an important factor in our civilization, and an increasing effort to secure the benefits of scientific research for particular political or industrial groups.

In attempting to evaluate the probable effect of science on the future, it is natural to look back and try to identify those phases of historical development that have been influenced by it. It is at least possible to pick out a few key situations and see what they suggest.

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It is a source of some embarrassment that science is regarded so widely as associated with means of warfare, and that its principal contribution to a nation is frequently, nowadays as in the past, considered to be the production of weapons of destruction. Scientists, in general, I believe, have been peacefully inclined, and have hoped that their efforts might lead much more to the alleviation of human misery, than to military victories. And yet one does have to admit that the applications of science in warfare are the spectacular ones. The peaceful uses are often taken for granted.

Nevertheless, although I hope and believe that the principal influence of science is not through means of warfare, this aspect cannot be overlooked. Scientific research has led in the past, and will probably lead in the future, to new methods of warfare and to new weapons. Hence, the research itself may be considered a weapon of war, and military promotion of scientific research can be regarded as a threat of war. It is for this reason, and in this connection, that there has been so much public interest in the matter recently.

Engines of war have been used for as long as we have had any record. Perhaps the classical example of the use of engineering in warfare is given by the activities of Archimedes during the siege of Syracuse.

Archimedes is known to all of you as the discoverer of the law governing the buoyant force on a body immersed in water. He was a distinguished mathematician, trained in the great school at Alexandria, and extremely productive in mathematics and mechanics throughout his life. His main absorption lay in the mathematical problems, and in some respects, he anticipated certain of the methods of integral calculus. But Archimedes was of noble birth. He was possibly related to Hieron, the King of Syracuse, and probably, from time to time, indulged in a little boasting as to the superiority of mathematical or theoretical methods over the engineering methods then in general use. Archimedes is reported to have grown so enthusiastic over the possibility of multiplying forces by levers or pulleys that in a burst of excitement he told the king, "Give me another place on which to stand and I will move the earth." But as is often true of relatives, the king was only moderately impressed. He perhaps responded with the ancient Greek equivalent of "show me." However, Archimedes was willing. Apparently, he did by means of some arrangement of pulleys or screws or levers, move a heavily laden ship a considerable distance, to the pleased astonishment of the king. This cousin had possibilities. He immediately found himself with a job. He was made Director of the Office of Scientific Research and Development, as well as Chief of Syracusan Bureau of Ordnance. He equipped the city with engines of defense such as had never been seen before, even though military engineering was extensively practiced by the Romans.

All of this was done in peace time, and for a while there seemed to be no urgent need for it. Nevertheless, Syracuse was a small city on the island of Sicily, caught between the ambitions of the two great powers of Rome and Carthage. There may have been many Syracusans who desired to remain neutral, but neutrality was no easier for a small power in that day than in this. After the death of King Hieron a party favoring the Carthaginians came into power toward the end of the third century B.C. It is quite understandable that the ambitious men of Rome could not permit a satellite state of their great rival to exist just off the toe of Italy's boot. Marcellus was sent to capture Syracuse, and it is from Plutarch's *Life of Marcellus* that we have the principal account of Archimedes' wartime activities.

The Romans approached with formidable forces both by sea and by land, and the common citizens of Syracuse naturally quickly felt they were lost. Archimedes, in addition to his previous activities, quite characteristically took on the job of Chief of Operations, and directed the defense of the city. Apparently he was able to command the confidence of the Syracusans, and it is reported that they all fell to and operated Archimedes' machines as he directed. The Romans themselves were not without engineering assistance in this assault. They had prepared a tremendous catapult floating on a deck of planks laid across a number of ships. Before it could be moved into position, however, Archimedes hurled at it numerous 50-pound rocks that destroyed both catapult and its supporting vessels. It is reported also that Archimedes had prepared long poles somewhat like booms on a derrick. These projected over the walls of the city and dropped great rocks into Roman ships. In other cases, these poles were equipped with grapples that actually reached down and picked up the Roman ships out of the sea, waved them to and fro, and dashed them against the rocks.

Even the hardy soldiers and sailors of Rome were naturally appalled at this. In spite of their leader's jeers that they were being defeated by a geometer, Marcellus was forced to withdraw his troops and settle down for a long siege. The siege was so effective that the Syracusans were apparently unable to get aid from Carthage, and began to experience the unfortunate results of depending on mere tactics for the conduct of the war. They could win the battles, but not the war. After two years of siege they evidently became so confident of Archimedes' ability to hold off the enemy that their vigilance relaxed, and Marcellus took the city by stealth. In the resulting confusion Archimedes was killed.

An interesting comment, made by Plutarch and others, was that this development of weapons for defense, which brought Archimedes so much fame, was regarded by him as of such secondary importance as to be beneath the dignity of mention. Archimedes left no written account of his weapons of war, nor has anyone else preserved for us a detailed description. In reading Plutarch's account, one is inclined to wonder if the stories are exaggerated; if perhaps they were the tall tales of old soldiers, or the alibis of a general who took two years to capture a city. Archimedes felt that his greatest accomplishment was finding the ratio of the volume of a cylinder to that of a sphere inscribed in it. Plutarch said that Archimedes requested his friends and relations to place a symbol illustrating this discovery over his tomb.

Of course, Archimedes was neither the first nor the last to apply engineering skill to military problems. In fact, until very recent times, military engineers were the only engineers, and the term "engineers" is said to derive from "engines of war."

Gunpowder was introduced around the thirteenth century, and new engineering problems immediately arose. Apparently the Chinese used gunpowder largely to make a great noise. The Europeans had a different objective, but their early results were about the same. Very little was known about the trajectory of the cannon ball, and the problems of ballistics began to assume great importance.

In the first half of the sixteenth century, Tartaglia, an accomplished Italian mathematician, attacked this problem and wrote a treatise on gunnery. This, again, was not his major contribution to science, for he is best known for discovering methods of solving cubic equations. A little later the famous Galileo, himself, gave attention to this problem and obtained the solution, in the absence of air resistance. Even during the recent war, this problem of the trajectory of projectiles was the object of attention on the part of numerous physicists and mathematicians.

Although engineers have been concerned with military problems as long as we have any record, it is only in recent years that organized studies have been made of them. It is only in recent years that this work has been much more than the efforts of relatively isolated individuals. For example, during the last century the histories of submarines and torpedoes show a succession of individual inventors undertaking to devise or to improve these weapons, and to sell their efforts to various governments, usually without much success. However, in World War I chemical research was officially organized on a large scale. In Germany, the Haber process for the fixation of nitrogen was developed to meet Germany's urgent need for nitrates. Later, crude methods for the use of poison gas were devised, and the chemists of all countries were immediately given the problems of perfecting these means, and of devising defenses against them. This scientific work was so thoroughly done, and the applicability of poison gas was so thoroughly analyzed and limited by defensive measures, developed at the same time, that every soldier carried a gas mask during World War II, but almost never did he use it.

During World War II practically all nations undertook to organize their scientific resources in an intensive drive to produce and to apply new surprise weapons. In the summer of 1940, a small group of Americans, headed by Dr. Vannevar Bush, organized the National Defense Research Committee with the object of placing the scientific and technical abilities of this country at the disposal of the government. Most of you know the nature of the success of this project.

The development of radar, centered around the Radiation Laboratory at Massachusetts Institute of Technology, provided a means of seeing in the dark, of seeing through clouds, and of detecting the approach of enemy aircraft or naval vessels at great distances. This work was done not because of the abilities of any one person, but because it was possible to bring together, in highly effective coöperation, a group of mathematicians, physicists, and engineers. They all contributed their respective skills and abilities to the consummation of this elaborate project. In this work each group came to respect the others. The electrical engineers came to realize that they could probably never carry on this kind of development as an extension of conventional types of engineering. The physicists were somewhat intermediate between the engineers and the mathematicians. They were acquainted with the experimental facts, and were able to apply them on a laboratory scale; but, on one hand, they leaned heavily on the engineers for the development of practical design; and, on the other hand, learned to depend on mathematicians and mathematical physicists for the detailed and quantitative analyses of their instruments and methods.

Another field, entered by the newly formed civilian committee at the beginning of the war, was that of anti-submarine warfare. During 1942 and the first half of 1943, the Germans were taking a terrible toll of shipping in the Atlantic. It looked for a time as though they might be able to enforce a blockade of Great Britain, and make an invasion of Europe impossible. Again a combination of mathematicians, physicists, and engineers devised ways and means of locating submarines, and of destroying them. They studied the propagation of sound in the sea and the various kinds of extraneous noise encountered. It was learned, for example, that in certain areas there are species of fish that make so much noise that communication by sound is almost impossible. They learned that under some conditions ships can be heard long distances through the water, under other conditions hardly at all.

Of course, the most spectacular result of scientific research during the war was the development of nuclear explosives. The basic principles underlying this development were known in 1941, but only a few physicists and chemists believed that these principles could be applied successfully; and, in fact, it was only through the coöperation of all sorts of people in a tremendous engineering project that the work was finally carried out.

It seems to me important to notice, in this connection, that most of the scientific research during the recent war was really engineering, and industrial development. It is one thing to formulate the principles of a military weapon or a method of warfare; but it is a much more elaborate thing to complete the engineering design, to set up the manufacturing organization, to arrange the facilities for distribution, and, finally, to provide the proper training for those who will use the weapon.

When the situation is viewed as a whole, the scientific research shrinks to its true significance, the significance of a seed compared to the tree that grows from it.

A United States general is reported to have said, "When Hitler started a mechanized war, he drove right down our alley." It was in facilities for production of automotive equipment that the United States excelled. The scientific basis of the automobile was known to the whole world, but only the United States was able to produce it in such tremendous quantity and in such wide variety. The same thing is true of other applications of science. It is a long and hard road from the scientific work to the final application, and it may be so long and hard that the scientific work becomes fruitless for military purposes. It is surely true that by far the great majority of the schemes and devices projected in laboratories during the recent war never reached the fighting front.

There is, of course, a great deal of discussion as to the best and most effective way of utilizing scientific research for the national defense. As a matter of fact, the scientific and technical laboratories of the Army and Navy are now being tremendously enlarged. This is now equivalent to the enlargement of the Army and Navy themselves, and can be interpreted, by those who wish to do so, as a threat of war. In this process, those in charge naturally undertake to conceal, by measures of secrecy, the work that is being done for military purposes. But many scientists are inclined to believe that the application of the principles of military secrecy to scientific research will, in a very short time, destroy the effectiveness of those working in that field. It is traditional in scientific research that there are no secrets, in spite of much public opinion to the contrary. A scientist of standing is always willing, and indeed anxious, to discuss his work with almost anyone who will listen, and it is only through such widespread discussion that ideas can be stimulated and brought to fruition. Hence, there is a feeling on the part of many scientists that the use and treatment of scientific research as a secret military weapon, will lead only to frustration. Many believe that, even for military purposes, more would be gained by maintaining throughout the country a high level of scientific and technical competence, ready at all times to devise, build, and operate new things, than would ever be gained by the possession of a few secret weapons. In particular, this belief is held because scientific ideas follow much the same lines in all countries. In case an idea is developed in the United States, it is quite probable that it is also thought of, and developed, elsewhere. It was interesting, at the end of the war, to see the number of parallel lines of development that had been followed in Germany and in the United States.

The present proposals of the United States government for the international supervision of atomic energy recognize these facts. They recognize that even though the present technical methods for the production of atomic bombs are kept secret, similar methods will be developed in other countries; and we cannot afford to base our own security, which is the primary aim in all our dealing with other nations, upon the keeping of an ephemeral secret. We can only expect to find security, through world-wide supervision of those who might develop such weapons of war. The proposal contemplates complete freedom of research and publication, but with the necessary accompaniment of adequate supervision, throughout the whole world, of all such activities that might be a threat to peace. This seems a highly reasonable proposal, but it is more than reasonable. It is a proposal that must be in some way put into effect, or our own possession of atomic weapons will be of no avail.

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But in spite of the large part now played by science in warfare, there are other points at which its impact on civilization may be even more significant. Consider for a moment the effect of applied science on economic competition.

The applications of science in engineering, agriculture, and medicine have already led to significant changes in the size, the distribution, and the activities of the world's population. Civil, electrical, and mechanical engineering have contributed to our civilization—first in the application of mechanical instead of human power, and second in the elaboration of means of transportation. Certainly the transition from an economy in which all labor was carried out by men and animals, to one in which most power is produced by mechanical means from natural sources, like coal and oil, is a stupendous change. We are accustomed to the concept that Greek civilization reached a high point of development several centuries B.C., but we seldom stop to analyze the fact that it was a civilization whose benefits could be enjoyed by only a few. The major part of the population was needed to do necessary and grueling manual labor. At the present time, the production of electrical power alone in the United States is such as to provide approximately five kilowatt hours per day for every individual in the country. Every man can consider himself followed and supported by an invisible laborer, able and willing to do part of the hard work. And this is only the benefit of electrical power. In addition, there is, of course, a tremendous amount done for us by steam power, and, perhaps above all, by the power of the internal-combustion engine, such as we use in our automobiles. Man is no longer the source of the energy for his work. He is only the directing intelligence. Even in those fields, such as the mining of coal, where a great deal of manual labor is necessary, the coal miner in many cases directs a coal-cutting machine, and uses his head, not his back, in doing the most effective work. Many of us have seen drawings, supposedly representing such ancient processes as the building of the pyramids, where huge armies of men carried the dirt and stones, much as a colony of ants might have done. Today as we look at the construction of new buildings, we see a few men operating steam shovels, driving trucks, and doing all the work previously done by hundreds.

The development of means of transportation is equally striking. No longer need a community be restricted to those raw materials and natural resources immediately at hand. Manufacturing operations can be based on material gathered from all corners of the world; and, in fact, the operations themselves can be spread over a wide area with convenient means of communication between them. No longer need a local crop failure, or a famine, deprive a region of its food supply. The mechanical means are available for distributing all kinds of goods quickly and cheaply.

The chemical industry, and chemical engineering, have contributed to our civilization most notably in recent years by the multiplication of the number of materials available for use. From fabrics, such as rayon and nylon, to synthetic rubber and high-test gasoline, the chemical industries produce materials to our specifications and to meet our needs and desires.

All of this activity has increased the general standard of living, at least in those areas where industrialization has been most effectively carried out. We nearly all dress better, eat better, live more comfortably than our forbears a century ago. The augmenting of the sources of food supply, has been accompanied by the medical applications of biology. Not only has the art and science of medicine led to a much increased life expectancy; but, through the discovery and use of vitamins, it is leading to a much improved quality of living. A man may live for many years on an inadequate diet, but his creative powers, his accomplishment, the quality of his living, can be increased by proper understanding of all the chemical requirements of the human body.

These various activities in the application of science have had important effects on the world's population during the past century and a half. As you may recall, the population of the world approximately doubled between 1800 and 1920. During this time the population of the United States was multiplied by about 20. The population of England and Wales, which were not influenced by extensive immigration, increased about 4 times. While there may be a great deal of uncertainty as to the detailed causes of these changes in population, it seems more than a coincidence that this great increase took place at the same time, and predominantly in the same areas, as the most extensive industrialization.

In addition to the general increase in population, there has been a change in distribution of population. The development of means of transportation has made it easier for people to move around, and has led to the development of vast new territories, like our own in the United States. The nature of the industrial development, and the economic advantages of large-scale production, have led to a concentration of population in cities or industrial areas, dependent upon rural or colonial areas for their raw materials. These increases in population, this redistribution of population, and the differentiation between the activities in rural districts and in industrial districts are widely recognized as creating some of the principal economic and sociological problems of the day. The real source of the trouble seems clearly, however, to go back to scientific, engineering, and medical developments. As these changes in industrial techniques continue, we must look forward to the necessity for continuing adjustments of this kind.

These applications of science are directed toward human welfare, the alleviation of want and misery, and the realization of man's best possibilities. But such objectives are not achieved at once. The influence of a new scientific or technical development has many ramifications and becomes felt in devious ways. Industrial development has created many and serious social problems, but they are problems to whose solution we can look forward with confidence.

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In spite of the way in which scientific research and engineering development have influenced our way of life, and in spite of the magnitude of the part that science and engineering play in warfare, I am inclined to believe that the most important influence of science on civilization is its effect on the attitude of mind of the people of the world. Science affects the philosophy of life of all of those associated with it.

May I read an excerpt from Mr. G. K. Chesterton on the importance of this kind of thing? It is included in William James' lectures on pragmatism:

> "There are some people," says Mr. Chesterton, "and I am one of them—who think that the most practical and important thing about a man is still his view of the universe. We think that for a landlady considering a lodger it is important to know his income, but still more important to know his philosophy. We think that for a general about to fight an enemy it is important to know the enemy's numbers, but still more important to know the enemy's philosophy."

Mr. James amplifies this by saying:

> I think with Mr. Chesterton in this matter. The philosophy which is so important in each of us is not a technical matter; it is our more or less dumb sense of what life honestly and deeply means. It is only partly got from books; it is our individual way of just seeing and feeling the total push and pressure of the cosmos.

It is difficult to be sure of the features of popular philosophy and opinion that are affected by science, but one or two examples seem possible. Consider for instance the position of a man in the sixteenth century as he looked at the world around him. The earth seemed like a tremendous place. He saw the stars mounted, he was told, on a crystal sphere surrounding the earth. The sun, and the moon, and the planets likewise, were ornaments and lamps for him and the earth. And then came the discoveries of Tycho Brahe and Kepler, and the observations made through Galileo's telescope, that led slowly, but irresistibly, to the conception of the earth as one of the planets about the sun. The scale of the universe was immediately changed. The comforting blanket of the sky had been removed. But that was not the end. It was discovered that our sun was only one of many suns, and that many of the stars we see are larger, and are an almost incomprehensible distance from us. In recent years we have learned that even the millions of stars we see constitute only our own system of stars, and that out beyond them are other systems of comparable magnitude, but so very far away that the mind is unable to comprehend the distances.

The understanding of this situation is certainly a major element in one's philosophy. Instead of the world being a very large, almost limitless affair, divided into innumerable little parts, our planet now becomes a very intimate home in which we huddle together against the desolate cold of outer space. And as one appreciates the magnitude of outer space, he tends to draw closer in spirit and in sympathy to all those who share this habitable sphere.

The discoveries in astronomy may have contributed greatly to our increasing understanding and knowledge of people around the world. Yet one may well imagine that a still greater contribution has been made by the increased means of transportation. When Jules Verne wrote his entertaining story *Around the World in Eighty Days*, he was emphasizing the speed of travel; and yet eighty days is long enough now to go around the world several times. In 1872, eighty days seemed short compared with the time taken on Magellan's first trip, but today one might try to do it in eighty hours. Magellan's crew reported many strange sights and many strange people. Even as late as 1872, Jules Verne's hero found himself in novel surroundings in faraway California. But today, as one travels around the world in a few days, it is not the strange sights that are impressive, but the similarity of one part of the world to another.

In any case, whether it is principally through the pure science of astronomy or the applied science of transportation, the fact of the unity of the world and the real brotherhood of man is becoming impressed upon every citizen today more than ever before.

Another thread of philosophy that can be traced from earliest times to the present day is designated by such terms as materialism, or mechanism. Among the Greeks, there were those unsatisfied with a superficial description of the changing appearances of things, and who postulated an atomic theory of the universe. According to Democritus and his colleagues, the universe was constructed of eternal and indestructible atoms moving about in restless flux, and so giving rise to rapidly changing appearances, but remaining always fundamentally the same atoms. As far as we know, the Greek atomists had no evidence for their explanation. It was not based on laboratory observations, but on the way in which it satisfied their minds. But minds could be satisfied in other ways, and for many centuries this idea of atomism lay dormant, with only occasional indications that it still had some life. With the beginning of what may be called the modern era of science in the seventeenth century, the idea again came to the forefront, and the work of a variety of chemists established the law of conservation of matter. It was shown that when coal is burned the gas given off, together with the ash that may be left, weighs as much as the original coal together with the oxygen consumed. They showed that when water boils it becomes steam, when wood burns it becomes gas, and in all the apparent changes that go on, physically and biologically, the total weight of the material involved does not change.

Conservation laws of this kind seem to appeal strongly to one's mind. We like to find something that is constant and permanent in the midst of all the change that goes on around us. Here is something to cling to. Here is something eternal and unchangeable that gives a feeling of security. This idea became so impressive that there were many to say the universe consists of the material atoms and nothing else. All of man's thinking and believing can be described in terms of atoms in his body and in his brain, and nothing else is needed. It has taken a long time for this idea to become widespread, but now some 200 or 300 years after its revival, it is probably influencing large groups of people.

During this same period of time another conservation law —the conservation of energy—has become of equal importance. First formulated by those who developed mechanics in the seventeenth century, it was extended during the nineteenth century to include heat energy. This was again the mechanical energy of atoms within material bodies, but later the law was extended to include such energies as we find in radio waves as well. Fifty years ago the principle became awe-inspiring in its generality. It was stated that the total energy of the universe was a certain constant amount. It could not be increased. It could not be decreased. It was always the same. This again was something to cling to, a rock in which one could place his confidence. There were then two laws of conservation—conservation of mass and the conservation of energy. These seemed to be twin pillars supporting the structure of a materialistic universe. Then about 40 years ago, as was described by Professor Wilson in the first lecture of this series, it was suggested that energy and mass are the same thing. That is, it is possible to change one into the other. It is possible to change the total amount of the material in the universe. The material that disappears becomes energy, and the material that is created, is created out of energy. The two pillars turn out to be the same, one law of conservation of mass and energy.

It is a very impressive basis for a philosophy, but just as the ideas of mechanics and the law of conservation of energy and mass are making an impression upon the minds of so many people, new discoveries have begun to throw doubt upon the very simple mechanistic explanation that some have wanted to give to the universe. Not that these discoveries affect the validity of the great law of conservation of energy and mass, but they do affect the very simple pictorial understanding that some people have had of it. The real consequence of these new discoveries in no way destroys the firm foundations upon which the scientific structure has been built. They only emphasize the vastness of our remaining ignorance. Newton said of his work:

> I seem a child that wandering all day long upon the seashore, gathers here a shell, and there a pebble, colored by the wave, while the great ocean of truth, from sky to sky stretches before him, boundless, unexplored.

Those working in science are usually extremely conscious of the vast unknown yet to be explored, but those who draw upon scientific results to support their own prejudices often overlook it.

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As one looks back over the records we have of science, there seem to be two fairly distinct lines through which we can trace the origin of our present-day body of knowledge of the physical world. On the one hand is what might be called the aristocratic strain. This includes the lines of mathematics and philosophical studies, stretching back to the Greeks, represented by the great academy at Alexandria; carried through the middle ages by the mathematicians and schoolmen who studied Aristotle; and represented today again by mathematics and the theoretical aspects of the sciences.

On the other hand is what might be called the popular strain, represented by the work and skills of artisans and engineers from the very earliest times. Of this we have very little written record. The arts of engineering and metallurgy, the manufacture of weapons, the construction of roads, household utensils, dyes, and glassware appear to have been handed down by word of mouth, from master to apprentice, and in only a very few cases ever reduced to writing. In fact, some of the arts of the ancients may have been lost. These two aspects are present today in every branch of science and technology. We have, on the one side, the theoretical sciences; and, on the other side, the arts of technology. To some extent the division is represented in our colleges and universities by the departments of science and the departments of engineering.

Occasionally, in the past, these two traditions have come into contact as in the case of Archimedes, in the case of Galileo, and in the case of Leonardo da Vinci. Upon these relatively rare occasions, the union of the two branches produced startling results, and the most recent accomplishments of science during the war have been clearly and definitely the result of the combination, not necessarily in one person but in one group, of the mathematicians, the theoretical scientists, and the practical engineers. For centuries these two traditions have been kept apart. Only recently have we begun to realize that neither alone can meet our needs, but both together can accomplish things much greater than we have imagined.

Science and technology are acclaimed on all sides as determining our future. There are those who look to this future with fear and apprehension. They fear that our knowledge is too wide, our power too great, for our moral development. They are afraid of the littleness of man, in the face of his own accomplishments.

But we can look forward with hope and confidence. The problems are great, but man has within the divine spark. He can press on to their solution.

There is no turning back; we can only go forward. We need not fear science. We can command it. In no light does man appear more competent, more nearly approaching the fulfillment of at least a part of his divine destiny, than when, with the necessary self-discipline, he obeys nature to command her aid.

Science and technology have made this one world, but long ago it was said, "He hath made of one blood all nations of men for to dwell on all the face of the earth."

W. V. HOUSTON.

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