The Shortage of Scientific and Technical Personnel:

What Industry Is Doing About It

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IN PRESENTING THE VIEWPOINT OF INdustry with respect to the shortage of scientific and technical personnel I would first like to raise three questions: Is the shortage of such personnel, from a long-range standpoint, as acute as we have been led to believe? Is not the real shortage one of suitability of such personnel for technical employment rather than one of numbers available for employment? Finally, should not our attack on the problem be aimed at development of scientific and technical personnel who are well qualified to succeed in the field rather than at turning out a greater number of such people, many of whom will not remain long in technical work?

Today our economy is so integrated that anything which affects one element in turn affects most of the other phases. Our economy has become increasingly technical. National defense, public utilities, agriculture, and industry have become more and more dependent on scientists and engineers for their survival and their growth to meet the increased demands put on them.

I believe that the situation in the automotive industry, with which I am most familiar, is quite typical of that found in industry as a whole. In the early days of the industry the average plant was small. New products and improvements in products already in production were largely the result of work done by inventors. These men did not necessarily follow any organized program in producing new developments, but, as they tried new ideas and found that they worked, they put them into production. Sometimes the ideas were good, and the product sold, but, if the idea was poor, the product was apt to be a failure. As evidence, think back to names of some of the automobiles built in the first decade of this century which are only memories today. As a rule, however, these earlier products were rather primitive according to our present standards. The improvements and advancements that could be made were fundamental and obvious. Thus, inventors working without any particular plan could show progress.

At that time each unit of product was manufactured and produced on an individual basis. The parts were made by craftsmen using the standard tools of the machine shop and employing the skills of the toolmaker and machinist. These parts were fitted and assembled by skilled mechanics working on a complete unit until it was finished. Little thought was given to manufacturing processes and better production methods as we know them today. Consequently, the cost of these early automobiles was high, and the demand for them was small.

But, as automobiles became more popular and the demand increased, manufacturers had to find surer ways of improving the product and cheaper methods of producing it. Better-organized product development, mass-production methods, and the assembly line came into being. The individual parts were made as nearly alike as possible so that they could be used interchangeably in assembling the product and to facilitate its repair in service.

This fundamental shift in the way the business was carried on required changes in method and changes in the kind of personnel needed. The scientist and the engineer replaced the inventor; trained and experienced designers were needed; and toolmakers, diemakers, and other skilled craftsmen made the tools to build the product instead of the parts of the product itself. These parts could now be made by men with less skill, each trained to run a specialized machine designed to do a particular job. The finished parts were assembled into units and these units into the final product on assembly lines by men also trained to do their particular jobs. The industry became more specialized, plants grew larger, and those with responsibility for developing the product, planning the manufacturing methods, and managing the business were required to have more technical knowledge and ability.

So, today, in modern industry an increased number of men with scientific and technical backgrounds, obtained through either formal education or experience, is essential to its functioning. Refinements and advances that can be made in the product and processes are smaller and more difficult to attain than in the first years of the industry. As a result, scientists and engineers now have to plan more carefully and use the techniques of the laboratory to carry on organized programs of research and development on materials, manufacturing methods, and processes in order that the product of the future will be better and can be built at a lower cost. Sometimes these research programs result in complete new industries that further

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increase the demand for scientific and technical personnel. New models of the product are designed, developed, and completely tested before they are put into production. Many of the men who supervise the building of the product have to have technical knowledge and skills to solve the day-to-day technical problems of production. In addition, the men who lay out the plants and plan the best routing of material and parts, as well as those who service the products in the field, need some technical training to do their jobs effectively.

There is an additional factor that, from our standpoint, contributes a great deal to the shortage of scientific and technical personnel. This is the problem raised by a sizable number of men who are trained in college for scientific and technical work and who, after a brief period of employment in the field, leave it to enter some totally unrelated type of occupation. These moves are usually made by individuals who believe they will find greater immediate returns for themselves in relation to happiness in the work, pay, or opportunities for advancement in the new activity. However, our experience has indicated that the reason may be a more fundamental one. Many of the men who make these changes are not fitted physically, mentally, or temperamentally for scientific or technical employment or, perhaps we should say, are better fitted in these respects for some other field of endeavor, and so they tend to gravitate away from technical work in their search for satisfactory employment. Whatever the reason, this group is to be found in every graduating class in every engineering college or technical school and reduces the number of men who are potential for the scientific and technical responsibilities in our future economy.

There are some contributions that industry can make in arriving at a solution to this problem of a shortage of scientific and technical personnel. However, a satisfactory and complete solution can be best obtained through the joint efforts of the educational institutions and employers of scientific and technical personnel toward achieving a better mutual understanding of the responsibilities involved.

In the first place, industry can do very little to increase the number of technical people immediately available for employment. This is largely the responsibility of the colleges and universities, and, since it takes considerable time to give science and engineering students their basic educational backgrounds, not much can be done to hasten the process. The immediate shortage is due to the fact that during the war years not as many young men were given an opportunity to prepare for scientific and technical work as in the years prior to the war.

However, while this immediate shortage in numbers of technical men available for employment exists, industry is doing certain things which help to relieve its effect. Veterans who went into military service immediately following the completion of a college or university course in science and engineering are being employed in positions for which we ordinarily recruit new graduates. Included in this group are many who were trained in military service educational courses, such as the Navy V-12 program. Men with scientific and technical backgrounds who were employed during the war years in temporary war jobs are being employed wherever possible. Maximum recognition is being given to the professional training of the experienced scientists and engineers already in our organizations in relation to their job assignments, in order that they may use their "know-how" most effectively. Quasi-technical employees, such as draftsmen, laboratory assistants, and experimental project mechanics, are found among veterans who obtained some specialized training in these fields while in the service as well as those who wish to go into industrial "on-the-job" training programs in these areas. All of these steps are aimed at the placement of technical and scientific employees in industrial positions where they can make their greatest individual contributions in relation to their particular backgrounds of education and experience. These efforts will help to spread the available supply of technical talent where it is most needed in industry until the present shortage is relieved in a few years by the graduation of larger classes now starting their science and engineering courses in our colleges and universities.

But from a long-range standpoint the problem is deeper than that of a shortage in the number of people educated for employment in these areas. There is also the problem of lack of ability to handle an industrial technical assignment among individuals who have passed the educational course requirements for this kind of employment but who do not possess the other qualifications needed. As I see it, the solution of this problem involves two things: better selection of those to be educated for industrial employment, and development of an attitude in the graduate that will help him to find his place in the industrial scheme more quickly.

Every field of work has rather definite requirements of knowledge and skills as well as of mental and physical abilities; every job requires some capacity to handle human relations problems; and every job requires specific interests on the part of the one who does it and should satisfy certain desires and ambitions on his part. Since the professional technical and scientific employees of industry are a part of management, their jobs have the added requirement that, to qualify to fill them, an individual must have the background on which to develop a management viewpoint and method of attack on problems.

So, to find the right person for a job we must find the applicant who has all the attributes required by that job. Some may argue that anyone can do any job to which he puts his mind, and this may be true in the exceptional case. However, most of us are better qualified for one particular field of work than for some other, and it is in

this field that we as individuals can make our greatest contributions to our employers, society, and ourselves.

A college degree in engineering, physics, or chemistry or good grades in specific courses are not enough unless the individual possesses the other abilities—the mental discipline, the capacity for dealing with people, and the interests the job requires. Only when we place on a job the individual who has all the attributes required in that job will we have an employee who is happily placed, will do his most effective work, and hence make the greatest contribution to the organization employing him. By making that contribution he will benefit himself. Therefore, the student who is interested in science or engineering should be assisted in analyzing himself and the fields of work for which he wishes to qualify. By the time he is graduated he should know what he has in the way of abilities, human relations attributes, interests, and desires that have been developed so far and will thus be in a better position to determine in what field he should seek employment—teaching, research, production, technical sales, etc.

What is the responsibility of our educational institutions in this connection? I believe that most of us will agree that for the majority of industrial jobs in the technical field an employee needs a good educational grounding in fundamentals rather than a highly specialized background. There are, of course, the exceptions of some highly specialized research and design jobs. He needs a good working knowledge of the physical sciences, mathematics, design, the laws of economics, and the psychology of human relations. He must be able to express himself clearly and forcefully either orally or in writing. An individual in whom the college or university has instilled this fundamental background should not be limited in his outlook or in the type of industrial job in which he can successfully develop.

But these are only his tools. He must learn how to use these tools. He must learn how to think clearly. Any curriculum in science or engineering should so prepare the graduate that he can apply the same scientific method of analysis to the solution of such problems as those of production, industrial relations, and business economics as he does when working a problem of research, design, or development. Industry is sometimes criticized by educators for not recognizing the professional status of all the graduate engineers in its employ because some of these are found several years after graduation in technicians' jobs that could just as well be handled by people with less training. The graduate engineer or scientist who, after he gains experience and knowledge, does not have the ability to solve major problems in the industrial field is no more a professional man than the doctor who graduates in medicine but cannot pass the state medical board examinations to practice.

Technical colleges and universities have the added responsibility of using the techniques developed by the psychologist and others who have specialized in the study of the behavior of people for better selection of those students who have the greatest aptitude for success in the fields of science and engineering. They have the responsibility of counseling their students and assisting them in analyzing themselves in preparation for their selection of the field of employment in which they have the best chance for success.

Each industry has the responsibility of furnishing the technical schools with pertinent information in regard to its policies, management philosophy, products, geographical scope, financial standing, and the educational backgrounds and attitudes expected in the graduates it employs. Industry is responsible for carefully analyzing its technical and scientific jobs in regard to the abilities, skills, human relations attributes, and interests required in each one and in regard to the personal desires each one will satisfy and for furnishing this information to the schools for student guidance purposes. Industry can inform the technical graduate about its training programs, benefit plans, and the opportunities it offers to a man with a technical background.

Industry also has the responsibility of training those graduates it employs and assisting them in bridging the gap between supervised development in the college classroom and self-development on an industrial job. Some such training must be furnished, since the colleges and universities cannot be expected to train individuals for specific industries. Industry, therefore, is responsible for furnishing the new employee with information on the products, processes, operating principles, and procedures of its organization. Through conferences with members of management he should have an opportunity to learn their methods of operation, philosophy, and point of view in preparation for the responsibilities that may lie ahead. In addition, during this preparatory period of employment he should be given working experience in the various phases of work related to the job and department for which he has been employed. Such a program, whether formal or informal, gives the employer a better opportunity to observe the performance of the individual in order to assist him in finding the specific field of work for which he is best qualified to make the greatest contribution in the years to come. While emphasis is put on intensive training during the first few years of employment and whenever the employee is transferred or promoted to a new job or another unit of the organization, it does not stop there. It takes a long time to learn the art of management, so his training, no matter how informal, will continue as long as he stays with the organization and grows in ability to assume greater responsibility. For this training to be effective, the graduate cannot start with an antimanagement point of view for, if he does, he sabotages the organization from inside.

General Motors feels that proper training of all employees is a very necessary part of its personnel program.

Each division has set up training programs to fit its individual needs. The importance of training is indicated by the fact that a central training agency—General Motors Institute—has been in operation at Flint, Michigan, for more than 25 years. The staff of the Institute assists the divisions and operating units in analyzing their training needs and in the design, development, and administration of programs to meet those needs. Management training for shop foremen and other first-line supervisors has been given considerable emphasis and has proved invaluable in developing an efficient organization. The Institute also operates a cooperative college course in Industrial and Mechanical Engineering which each year furnishes our various plants with more than 150 graduates, each trained for specific responsibilities in the technical and manufacturing phases of the business.

Training helps the employee to orient himself to the organization and to learn to apply whatever fundamental educational background he has to the job at hand and to the ones that lie ahead. It is one of the best ways of assisting the employee in getting the most out of his job.

With the cooperation of industry the colleges and universities should be able to do a better job of student selection and counseling, so that those who are graduated and enter the technical and scientific fields will have a better chance of success and will be more apt to make a career of these fields.

In addition, there is the problem of developing in the technical or scientific student an attitude needed for industrial employment. After all, he is not recruited as a factory laborer or into a routine job in which he will spend the rest of his life. He is employed because management believes he has possibilities for development into a management position himself. A willingness to work on any phase of the job to be done, a willingness to accept criticism and suggestion, a willingness to become a part of management and to accept the responsibilities of management are all a part of this attitude.

In order to give a better idea of what we mean by attitude as it relates to the college graduate going into industry I would like to quote from a talk given by William E. Wickenden, president of the Case School of Applied Science, at the General Motors Institute Commencement in August 1946:

> ... But there is another thing, which seems far more important, which you can do uniquely perhaps, and that is to make the process of education bridge over the gap between school and practice in which so many men seem to lose the momentum of intellectual mastery and professional growth. The most important thing anyone can learn in school is not some collection of items of knowledge or tricks of skill, but the art of carrying on his own education without a teacher's supervision and the conveyor belt of a curriculum and academic schedule. That art, I regret to say, we too often fail to develop or, if we do, it will too often fall a casualty in the first few months out of college....

Finally, it is most important that the graduate have a firm belief and complete confidence in the policies and management methods used in the organization he joins and that he be motivated not only by what he hopes to gain personally from the company but also by a desire to make a contribution to it. It is fundamental that, if any student leaves college with the opinion that the present system of industrial management is subject to serious question, he will have great difficulty in fitting into and becoming an effective part of the management group. If this is not his objective, he should not look to industry for his opportunities.

Unfortunately, not all members of college or university faculties have had an opportunity to gain industrial experience and, as a consequence, not all of them are prepared to give their students a very realistic picture of what to expect when they take industrial jobs. Many men in technical or management positions in industry have not had an opportunity to obtain a firsthand knowledge of the problems of the engineering school. Too often their opinions of educational courses or of a particular educational institution are based on hearsay or an unfortunate experience with a few poorly prepared college graduates. Some of them feel that students are often taught courses dealing with the way the instructor or textbook writer would like to have industry do a job rather than courses explaining how it is actually done. We cannot expect members of the college faculties to give their students anything of management's viewpoints unless they have been given an opportunity themselves to study at firsthand and appraise these viewpoints as they are applied in different companies. I believe that conferences between educators and men in industry who employ technical graduates, where information is exchanged and where college courses and industrial training programs are constructively criticized, will do a great deal toward the solution of these problems. Faculty members would then be better equipped to develop in their students a broader and more realistic viewpoint and prepare them to make the shift from college into the industrial field more readily. Industrial management will be better informed as to the backgrounds of education and attitudes of the graduates they employ and more sympathetic toward their problems of orientation to industry.

During the last two years we have held short summer conferences of our management with educators in the fields of industrial relations and personnel. The purpose of these is to give a group of college and university men who are teaching courses in labor relations and related subjects an opportunity to observe at firsthand our methods of handling problems in these areas. At each conference the educators first met with members of our personnel staff. Next each educator was sent to one of the company's plants and given an opportunity to observe for several days any phases of the personnel program and to discuss his observations with members of plant man-

agement. Finally, the group returned to Detroit and, after spending a day exchanging ideas obtained from their plant visits, presented their comments and suggestions to interested members of our Corporation management, the personnel staff, and personnel representatives from our divisions and plants.

In order to give a greater number of educators an opportunity to gain this kind of experience so that they will be in a better position to present their students with a more realistic picture of what they can expect when they accept industrial employment, this experiment should not be confined to one company or one field of education. We should consider its application or the application of other methods to the fields of science, engineering, finance, and distribution, among others.

I firmly believe that by pooling the experience and "know-how" of employers with that of faculty members and administration of our colleges and universities we will find better ways of producing technical and scientific graduates who are better qualified to do their jobs and more interested in making these fields a career wherever they choose to accept employment. This cooperative attack from a long-range point of view will, it seems to me, help to insure more effective use of technical and scientific graduates in industry. This may be more important than producing a larger number of graduates, many of whom leave this field of work after they are trained for it. Let us put greater emphasis on producing quality rather than on just increasing the number of graduates in the technical and scientific fields.

The Scope of Science

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WHEN, SOME MONTHS AGO, I FIRST read the paragraphs in British publications which provide the text and motivation for this article, I was so amazed and dismayed by what seem to me partially erroneous and wholly misleading statements that I felt impelled to make immediate reply. But on further reflection, being of a noncontroversial disposition and much averse to giving my time to expression of disagreement, I inhibited the impulse. Recently there have been developments which brought the matter to my mind again, and this time with such sense of duty and opportunity that I am now offering critical rejoinder and alternative view. Unwillingly I write in the first person, since I may not assume that the British writers speak for their scientific colleagues or the British people, and since I have no mandate to represent my scientific colleagues and my fellow citizens of the United States of America.

The first half of my text appears in the following paragraph from an editorial entitled "The method and scope of science," published in "a quarterly review designed to record the progress of the sciences in the service of mankind," which is "made and printed in Great Britain." The journal is called *Endeavour*.

> It is, however, in the realm of qualities not susceptible of measurement of any kind that the scientific method—as far as it has yet developed—ought frankly to be recognized as *inapplicable*. An obvious example can be taken from the field of art. The scientific method can give a great deal of information on the chemical nature of pigments, on the wavelength of the light they reflect, and on similar factors, but *it is wholly unable to predict* whether a picture will have an aesthetic appeal to those who see it. *Nor can the scientific method be of help* in those problems relating to drama, literature, and the like, which involve *qualities that cannot be measured* and knowledge which is not communicable. In the wide field of human affairs *the scientific method cannot be applied*, even in the form of statistical analysis, to problems in which events are influenced by the philosophical values of goodness, truth, and beauty, and emotions such as patriotism, fear, or political conviction (*Endeavour*, 1946, **5**, 126). [Italics by R. M. Y.]

In this emphatic statement of opinion I should wish, on the basis of my knowledge of fact, to convert all the negatives—the impossibles and improbables—into positives. Thus "inapplicable" becomes "applicable"; "it is wholly unable to predict" becomes "it is partially able to predict"; "nor can the scientific method be of help" becomes "the scientific method can be of help"; "qualities that cannot be measured" becomes "there are no qualities of natural phenomena which cannot be measured, although at present there are many which are not being measured or are measured very crudely and inaccurately"; and "the scientific method cannot be applied" becomes simply "the scientific method can be applied to all natural phenomena."

Actually, what the writer of the editorial deems impossible I have observed being done in what chances to be my country, culture, and sphere of creative scholarship, on all sides and increasingly throughout my life. For nearly 50 years most of my time and intellectual resources have been devoted to efforts, sometimes recognized as successful, to do just what is termed impossible