THE RELATION OF SCHOLASTIC ENGINEERING TO INDUSTRY FROM THE STANDPOINT OF THE MECHANICAL ENGINEER

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This assembly marks, primarily, the dedication of "Evans Hall," the new engineering building of the University of Delaware.

I am honored to be among those guests invited to witness and participate in these proceedings, and, at the request of Dean Spencer, to address you on the theme, "The Relation of Scholastic Engineering to Industry," more especially from the standpoint of the Mechanical Engineer.

Industry needs and welcomes the founding and extension of engineering schools of this order. Men with minds trained in special branches of engineering by such institutions as this are essential to industry in the solution of problems now before it and those that will mature in the future development of our industrial progress.

"The Relation of Scholastic Engineering to Industry" is a broad subject.

The art and science by which the mechanical, physical, and chemical properties of matter are utilized in structures, processes, and machines for the benefit of mankind defines "Engineering," while "Industry" represents any department or branch of art, occupation, or business devoted to the production of structures, appliances, and commodities essential and useful to our civilization.

It is apparent that all "Engineering" and "Industry" in their separate divisions are similar and relative. Thus one thinks of chemical engineering as intimately associated with the chemical industry; marine engineering with the shipbuilding industry; efficiency engineering

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with the manufacturing industry; and so on indefinitely. It is to be observed at once, however, that no specific industry is dependent on only one branch of engineering, but as our material progress advances, industrial development multiplies in complications and many special engineering problems must be dealt with in a single division of industry.

I propose to discuss the two major portions of the theme assigned, with specific applications, in accordance with my own special training and experience, and I choose therefore the Electrical Industry and Mechanical Engineering. A discussion of these relations requires first, a retrospective view by which we may freshen our memories of the past; second, a consideration of the present conditions of our environment; and third, a contemplation of what the future may have in store.

Let us first consider the past.

Some three thousand years ago Tutankhamen, a Pharoah, was entombed surrounded by his wordly goods, apparently in the belief that his spirit would have need of these material things to perpetuate his disembodied soul. Through the superstitions of this king, archaeology has been enriched and the Pharaoh's relics have revealed new knowledge of the art, manners, and customs of the time when Egypt enjoyed the zenith of her power and glory.

One hundred years makes little difference in reckoning the date of Tutankhamen's burial. Speculation can easily span that period of time in any consideration of the subject. The cycle of events that then occurred is so remote from us and so unmarked by great material achievement that a century of time ceases to convey any sense of proportion.

From the boyhood of our grandfathers down to the present day spans only a century of time, but this period has witnessed the most stupendous advance in material civilization that the world has yet known.

Until the insistence of Francis Bacon was accepted, that man is the servant and interpreter of nature, that truth is not derived from authority, and that knowledge is the fruit of experience, all history, as far as material progress is concerned, is a story of human energies dissipated and natural resources undeveloped and unused. Bacon's emphasis on analyzing and testing the old accepted facts of nature by the experimental method sowed the seeds that developed the great material growth of civilization to full fruition in the nineteenth century.

From the time of the ancient Egyptians down through the Dark Ages, men were primarily engaged in forcing various religious and political beliefs on the human race. Constant turmoil and wars of conquest were the inevitable result. In the Egyptian, Greek and Roman civilizations material progress was made principally along architectural and constructional lines. Much of the ancient philosophy lay dormant for centuries and very few inventions useful to man were made until through a desire for truth the reasons for natural phenomena were cross-examined and the secrets of nature could no longer be withheld.

On the principle established by such pioneer investigators and original thinkers the great material progress of the nineteenth century was founded. After them came the men of applied science to give the world devices operating on the principles and laws enunciated.

In the long list of noted American inventions the lightning rod by Franklin, in the middle of the eighteenth century, is the earliest. His research on electrical phenomena, followed by Galvani, Volta, Ampere, Ohm, Wheatstone, and others in early nineteenth century, marked the dawn of electrical development.

Almost simultaneously with the announcement of electrical discoveries came the development of the steam engine for the production of power from the resources of nature, and yet at the time our grandfathers began to look out on life, little change in the material environment of civilization had occurred through the ages. A century ago there was not a railroad in all America or Europe, and transportation was conducted by methods no different from those of the ancients. The steamboat was a doubtful experiment and subject to the ills of all pioneer devices.

Communication was carried on by horse or messenger and people lived without intimate association and in ignorance of events occurring in other parts of the world. Coal was just coming into use and mineral oil had not yet been discovered. People burned wood to keep them warm in winter. There were no furnaces, no bath tubs, no hot water faucets, no sanitary conveniences. There were no sewing machines, electric lights, telegraphs, telephones, radios, automobiles, or aeroplanes; in fact, none of the modern conveniences and appliances which we count today as necessities was then available.

The general field of modern mathematics, physics, and chemistry was just beginning to be explored. Surgery and medicine did not include anæsthetics, antiseptics, and antitoxins. Many subjects now found in any college curriculum were still unknown.

For the first fifty years of the nineteenth century men were busily engaged in applying and developing mechanical and electrical inventions based on experience the previous generations had made available through research and pure science. A vast store of knowledge and understanding was beginning to appear, and as investigation feverishly advanced useful devices materialized.

In the electrical field the absolute necessity for a prime mover to generate current was recognized. The steam engine was at hand to supply the need, and power-generating units, consisting of steam engine and electric generator, became available.

The Electrical Industry began its real commercial advance about fifty years ago, a period well within the recollection of many now living. This development was mainly haphazard, following the lines of least resistance. No one fifty years ago could predict its possibilities and those who did venture to estimate its probable growth were derided as visionaries. The invention of the incandescent lamp by Edison and his plan for the central generation and distribution of electric current for lighting purposes were of prime importance.

Morse with the invention of the telegraph in 1835 annihilated distance, advancing the importance of rapid intercourse, and Bell in 1876 gave us his splendid achievement of the telephone, which with the later developments in wireless telegraphy and telephony have revolutionized the art of communication.

By the Edison system of central station generation and distribution of electric current it became possible to furnish by a wire at any desired point those three prime essentials to material advancement: heat, light, and power. While the central power stations were originally conceived for the purpose of electric lighting, they were soon offering current industrially, for railroads, for street cars, and for domestic and other purposes. By invention and development, the ability to transmit power electrically in large quantities made it possible to serve extended areas from a centrally located power station with its transmission and distribution system.

The uses for light, heat, and power supplied electrically developed so rapidly in the past twenty years and the amount of current required by our enormous industrial expansion became so great that an excess of demand over supply resulted and the power stations found themselves unable to furnish all the requirements of their customers, notwithstanding a continually increased program of expansion in power station and distribution equipment.

What, then, is our present environment with relation to the electrical art?

The skillful hand, aided by the perceiving eye and the directing mind, the contemplation of the facts revealed by investigation, and the logical arrangement of the phenomena perceived and conceived in any investigation for truth, have given us the knowledge which has permitted the industrial growth we have accomplished in our modern civilization. The present status of the electrical art could not have materialized without a fair knowledge in other fields of engineering. In the material advancement of the past century the strong hand of research has gripped innumerable essential facts in nature and by a process of elimination has isolated the important elements on which to found a law or lay down a principle.

Of all the known sciences, electricity is still as obscure as any other. This world of ours is so involved, so wonderful, that the further we advance in knowledge, the more are we impressed with the *relative* nature of all facts and phenomena. The material development we enjoy would not have matured through a great knowledge of one essential division of nature. It has come about rather by the acquisition of some knowledge of many or all of the divisions.

We have reason to believe that relations do exist between certain phenomena. Our human senses, for instance, tell us positively that there is a wide distinction between the electrical parts of a motor and its mechanical construction, and yet no electrical appliance exists that does not combine these two divisions of engineering in some relative proportion.

We know that an automobile, essentially mechanical in its construction, would be useless without the electrical equipment to ignite the gas in the operation of the engine. We might manage to get along without the starter and supply the power required for starting by hand-cranking the engine, but the engine would not function without the electric ignition.

No machine, electrical or otherwise, has ever operated successfully with any of its essential parts missing. Similarly, no one art or science is responsible for our present conditions. Mechanical and electrical engineering have gone hand in hand in the past and must so continue, together with other specific branches of engineering.

With the advent of steam and electricity, we have developed means of transportation and communication far beyond the wildest dreams of our forefathers. We cross the continent in less time than our grandfathers required to make a wearisome journey from Lancaster to New York. With an electric locomotive we haul a heavy train over the Continental Divide and in descending the grade on the east slope of the Rocky Mountains we put as much power back into the line for use elsewhere as was required to ascend the west slope.

Under the earth's surface we are transported in comfortable trains, electrically operated and at speeds unknown a hundred years ago, while above us the streets of a great city are crowded with traffic in a hectic rush of horseless vehicles. Electrically we travel for hours submerged in the sea. We change our course and our depth or rise to the surface at will. We fly from London to Paris in less than three hours, outdistancing the swiftest bird, and traverse the remotest parts of the earth in airship and aeroplane.

By our transportation systems we supply the essentials of life to masses of people congregated in huge cities and handle from distant points the raw materials which keep the workers engaged in producing the finished products necessary to our environment. As the industrial advancement progresses we vastly increase our transportation capacity and efficiency by substituting electric operation for steam. We concentrate in central power stations the generation of power to be fed through a wire to the locomotive and power units as they require it. We cross the Atlantic in huge ships more luxuriously appointed than the palace of a king a century ago. We spend five days in rest and comfort making a journey that would have taken our grandfathers more than a month of tiresome travel to accomplish. On our state highways we rapidly traverse long stretches of country and become familiar with locations we would never see without our automobiles.

To match this speed and development in transportation and to carry on our daily routine of business we write a telegram in New York to be delivered in San

Francisco in an hour. We carry on conversations with our friends or business acquaintances hundreds of miles away and we hear at will news items, speeches, concerts or lectures carried to us by wireless telephony. By the use of the photophone and wireless transmission we record and reproduce instantly and in series, with complete accuracy of detail, scenes enacted and sounds emitted thousands of miles away. In the heat of summer we cool our rooms with electric fans, or warm our feet on cold nights with an electric heater.

In a hundred ways we use electricity to comfort and aid our daily lives. Its uses in medical treatment and in dentistry are manifold and in the synthetic construction of compounds it has given us materials which even nature herself has not known. In the realm of domestic science we save labor and promote efficiency by the use of electric current. We cook, sweep, wash, iron, and sew with its aid, and perform any task which may involve the use of light, heat, or power. Surely the electrical art holds high rank in our modern civilization! It has become a vital and essential part of our daily lives, and its stupendous development has not only revolutionized our environment but has completely changed the method and manner of our living.

Perhaps we are progressing too rapidly and may pass beyond our capacities to control the vast forces in our mechanical era. There are those who believe our civilization has over-expanded; that our capacity for knowledge is limited and our abilities for bearing responsibilities do not warrant such rapid developments as we are undertaking. It is argued that advancement cannot continue in the same proportion in the future that has characterized the past three generations. How are our capacities to take on and carry forward the huge responsibilities and burdens which the present and future may thrust upon us? We have seen that, with each increment of knowledge gained, many new problems arise for consideration and solution. How can we master and control all the varied functions that must affect our lives?

The founding of Evans Hall is a partial answer to these questions.

An electrical engineer was unknown a century ago, but conditions of material progress have required a specialist to cope with this branch of our knowledge. It is conceivable that generations ago one might have acquired a fair proportion of the body of human knowledge, but its boundaries have so expanded, its ramifications so extended that this is impossible today. Specialization and organization are the complete solution of all these questions. In engineering matters we have been compelled to classify and subdivide. In place of all engineering being concentrated in the Civil profession, as was formerly the case, we now have many branches, such as electrical, mechanical, civil, mining, metallurgical, automotive, sanitary, marine, etc.

But as Dr. Robert Millikan puts it—

"None of these branches of engineering or indeed any industry would have been possible without two hundred years of work in pure science—work beginning in the sixteenth century with Copernicus, Kepler, and Galileo. Their discoveries for the first time began to cause man to glimpse a nature, or a God—whichever term one prefers—not of caprice or whim, such as had been all the gods of the ancient world, but a God who rules through law, a nature which can be counted upon and which hence is worth knowing and studying."

"Their discoveries, which began to be made about 1600, were the supreme discoveries of the ages, for before any application was ever dreamed of, they began to change the whole philosophical and religious outlook of the race. They began to effect a spiritual, and intellectual, though not at first a material, revolution."

Through the subsequent generations of our development, the discoveries of the laws of nature and their formulation for use have given us our present basis of scholastic engineering. If we are to control and carry forward this material progress, schools such as are provided here are indispensable, that those who follow us may achieve the technical training necessary to a full understanding of the branches of scholastic engineering so vital in the advancement of our civilization, for

> "Through seas of knowledge we our course advance,
> Discovering still new worlds of ignorance."