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WHAT THE TECHNICAL SCHOOLS EXPECT OF INDUSTRY[1]

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THE topic which the distinguished president of Lehigh University has invited me to discuss on this occasion is "What the Technical Schools Expect of Industry."

Permit me to suggest that before we discuss a "What" we should reflect on and disclose whether there may or may not be a reasonable "Why." That is, we should consider whether there are reasonable grounds on which the men who control the scientific and pedagogical processes and progress in the engineering schools can establish a just claim on the intellectual and financial interests of industry. Permit me to diverge briefly and dispose of this question, in the interest of then being able to more clearly unfold my principal theme.

[1] Address delivered on the occasion of the dedication of the James Ward Packard Laboratory of Mechanical and Electrical Engineering, Lehigh University, October 16, 1930.

The application of the words "industry" and "industries" in this address is to the engineering industries, and these words thus used are inclusive of substantially all collectivities engaged in manufacturing, transportation, generation and distribution of power, production of artificial light, communication of intelligence over distances. These compose the broad foundation which, next to sentiment, ethics and religion, supports our twentieth century civilization. Even agriculture, a basic and pervasive activity, now secures part of its character from these engineering industries through the inventions that have given birth to automobiles, tractors, hard-surfaced roads, manufactured fertilizers; in addition to the older railroad, electric light and power, and telephone industries. We thus are discussing a topic which touches the welfare of every ultimate citizen. The wise administration, the continued unfolding of new aspects, the

prosperity of the engineering industries, are the concern of every individual among all classes of citizens, rich and poor, exalted and lowly, alike. That discloses a responsibility and a scope in the industries sometimes overlooked, which gives one side of the answer to our "why." Engineering works provide the veins, the nerves, the sparkle and the vital functions which vitalize modern civilization. Agriculture continues to provide the food supply. The government has found it necessary to furnish guidance and support for the functions of higher education and research in the latter. Industry is able to cooperate in the support of these functions applied to the former, and better progress can be made where industry embraces its part in the cooperation and by its achievement illumines the features that economically may be supported by government.

With our abundance of opportunities for new or improved utilization of forces and materials and preventing waste of man-hours and natural resources, the prosperity and influence of the industries are bound up in improving on the old, well-beaten, wasteful paths of practice which have been determined solely by empiricism. For the supply of men to be relied on in development—the unfolding of new fields and improvements in the old fields—industry has come to rely more and more on the colleges and particularly the engineering colleges. This is another side of the answer to the "why." Engineering school men are coming more and more into elevated administrative posts where wise administration must be in command, in addition to carrying on in the designing, manufacturing and selling branches of industry. Scientist or engineer can become a great merchant if he has the taste and will to be. The business man who is pure empiricist has proved to be more than 50 per cent. failure. Creative intelligence in management and ability in scientific research are two assets for a people that can not be too highly valued. On our success in stimulating them we may confidently rest our future.

Development in the industries is largely the result of additional applications of well-established science or (less frequently, but often most fruitfully) of applications of newly discovered facts or modes of reasoning. For making the discoveries, industrial society must largely rely on the school men. The universities in all their branches, including the engineering schools, are educational institutions and the making of men (a pedagogical process) is a primary function for them, but research is an important parallel function both as a part of the pedagogical process and as a means for testing empirical philosophies and extending knowledge by discovery. The engineering schools are proved to be capable and successful in the prosecution of these two functions; the products of these functions are highly important to the financial prosperity of industry. This is a third side of the answer to our "why." We of the engineering schools believe that these *a priori* grounds make a sound reason for industry to contribute financially for the purpose of aiding the engineering schools to improvement in prosecuting these functions, but to direct such contributions only to such schools as are qualified by the possession of the spirit of progress.

Engineering education has for its end result the attainment of knowledge of the ways of nature and man, intelligence in the command of circumstances, resourcefulness in the use of knowledge, a spirit of investigation into the phenomena of nature, powers of exact analysis and synthesis, and an instinctive sense of the relative fitness of things. The days of the old-time empiricists who carried on according to the ways of their fathers solely because their fathers did so before them are almost gone in engineering and the engineering industries. The days of intelligent application of science and the now known principles of economics have dawned. The necessity of widening the applications of science and of farther disclosing applicable economic principles is recognized in engineering and has become a factor of engineering education. The pinch of necessity seems always to produce improved intelligence; which is a corollary of the theorem that the fittest in intelligence survive and radiate their influence to the ends of the earth. No education is directed to a finer end.

Before going farther it is reasonable to search our souls with the inquiry whether we of the engineering schools are performing the two functions of the making of men and of prosecuting research in such a devoted and impartial manner that support of the performance from industry at large may be justly expected. Have we thrown empiricism sufficiently to the winds in our processes and joined the band of scientists and economists who pursue, disclose and correlate all facts, endeavor to discover new facts, and fit all together in an intellectual and physical embodiment without being overly-trammeled by tradition? If we have not, then we must step forward under internal compulsion before relying much on external support.

Our alumni and others of either sex who advise their sons and the sons of friends to become our students have the right to inquire into our ways. They may ask whether we thoughtfully assay our pedagogical methods and strive to elevate their quality; whether we suitably recognize those distinctions be-

tween students which arise from present differences in intellectual maturity and speed, and encourage the development of each student to his fullest individual capacity; whether we encourage exercise of each individual student's self-reliance and resourcefulness; whether we secure reasonably complete intellectual contact between students and faculties to aid in enriching the sense of responsibility, loyalty and character of every student; whether we utilize a fundamental and scientific approach in the subjects pertaining to our teaching and also in the formulation of our curricula; whether we appreciate the importance of placing empiricism in engineering in a less important place in our teaching and utilizing it only to fill up gaps left by the inadequacy of the organized knowledge known as science; whether we are achieving a closer articulation of the principles of economics with those of science; whether we are developing a sound investigative spirit in all our students; whether we are associating formal scientific research with mature students' work so that students may know by experience the effectiveness of a sound marshalling of facts as a basis of judgment instead of much that goes by the name of judgment but in reality is merely guessing; whether we are bestowing wise selection and supervision on younger members of teaching staffs and are seeking to establish greater selective rewards in the way of distinction and financial compensation for established achievement by staff members; whether we all embrace the golden tenet that pedagogy and scientific research should be bedmates in engineering education.

Frankly facing the situation, we can see the need for improvement in the aims and practices of the engineering schools. Nevertheless, their educational ideals and practices are unexcelled in the field of higher education in the United States. Our logically coherent curricular programs, set out in sufficient variants to satisfy the intellectual tastes of the variety of students who choose to enter the field of engineering, associated with freedom of election and substitution by individuals who have reached the maturity to demonstrate fitness for making their own "case," have been a steadying and rectifying influence in national higher education. Moreover, we know that improvement in our processes is being made and will continue to progress.

Although such questions as those enumerated in the second preceding paragraph may be asked justly by patrons of our students and supporters of our engineering schools, there is nevertheless an amplitude of evidence of successful results rising out of our performance to plentifully answer our "why" and justify a claim for selective support far larger than has yet been extended to engineering schools by the industries. This is shown by the reports of the recent comprehensive analysis of aims, processes and results of the engineering schools made by committees of the faculties under a coordinating committee (called the Board of Investigation and Coordination) which was appointed by the Society for the Promotion of Engineering Education. Financial support supplied by the Carnegie Corporation for a director of investigation with his aides and headquarters made this important study possible.

Time lacks for me to give a full exposition of the undischarged debt of industry in this country to the engineering schools. I must now content myself with a few briefly stated illustrations.

Aside from distinguished inventors and executives who laid the early part of the structure, many of whom continue in great achievements but whose days of youthful education were over before the engineering schools sensed the importance of industrial development, it is a matter of commonplace observation of the electrical industries that a notable proportion of the men in executive or developmental positions who are now advancing these industries to greater service, influence and prosperity are alumni of engineering schools. As far as these industries are of value to the citizenry of this country by increasing the comforts and conveniences of life and by enlarging the hours of leisure, so far the citizenry have a debt to these men and a debt to the engineering schools from which many of the men secured education and stimulation in their youthful days. As far as the vision of these men has contributed to the prosperity of the industries, these industries, their employees and stockholders also owe some debt to the engineering schools for the contribution of their part in the education of these men.

The executive and operating affairs of many of our most prosperous and serviceable railroads are in the hands of men whose youthful schooling was in some engineering school and from the fertilizing influence of which the individual's present ideals and ambitions may have been aroused. The steel industries are slowly turning from empiricism to engineering science for the betterment of their methods. The textile industries located in New England might well have been in a happier condition to-day, had they not notably lacked in the scientific spirit characterizing engineering in this generation.

Mr. James W. Gerard (former American ambassador to Germany) recently came forth with a list of names of sixty-four men who, he was reported to allege, "rule the United States." The list was marshalled in argument supporting a special cause and

Americans speedily denied the possession of his selection of the power to rule this nation. However, it is sufficient for our own purpose here to agree that each of the names in that list attaches to a man of magnificent achievement who is in high and useful influence in finance, commerce, industry or social relations; and that every one, whatever his primary leaning may be, has had a large influence directly or indirectly in establishing, widening or increasing utility of the output of industry in this country. It is a pertinent fact that 17 per cent. of these men are engineering school men. The proportion of engineering school alumni among the total of ambitious men in this country is much smaller than 17 per cent., and some decades ago, when these men on Mr. Gerard's list were entering industrial life, the proportion was still smaller. It appears from this list, as far as such a list may have pragmatical weight, that the engineering school processes in education have a proved vitality. Creative intelligence in management is a triumphant but elusive fairy; however, she is no will-o'-the-wisp that can not be captured as an embodiment. In fact, she seems to favor association with the educational processes which characterize our engineering schools.

With this academic year I enter upon my fortieth consecutive year as head of a department of electrical engineering, first at the University of Wisconsin, beginning when electrical engineering instruction was established in that institution, and latterly at the Massachusetts Institute of Technology. This long period of employment in these two great universities has afforded unrivaled opportunities for observation and reflection on the development and status of engineering education. In the earlier days, the engineering schools were looked upon askance alike by the industries (on the ground of alleged lack of "practicalness"), and by the so-called liberal colleges (on the ground of alleged "narrowness"). Among the engineering faculties we were far from agreement on aims and differed radically amongst ourselves regarding the relative weight to be attached to exact science, scientific research and formulated economics, as supported by one group, and empirical engineering practice as supported by another group. Latterly these fogs have blown to one side. Experience has disclosed the relative merits and demerits of the principles supported by the different parties in engineering education.

Our vision now is clearer and more far-reaching. Our educational processes stand unexcelled in results and in repute. Fully awakened to the importance in education of utilizing scientific research, we emphasize the science, scientific research and economics in our curricula. We use empirical practice as material out of which to build illustrations and contrasts among the present applications of scientific methods in engineering, to demonstrate possibilities of the betterment of practice through the fruits of research, and to map paths that may lead to such fruits if unswervingly followed. Influences of this nature, though then quite crude, are the influences under which were placed as students that 17 per cent. of Mr. Gerard's list who are engineering school men, considering one by one these men and the engineering schools in which they studied.

In the engineering schools, we believe that engineering is second only to preventive medicine in influences which improve the comforts of populations and widen to all individuals the opportunities for desirable living. We men of the engineering faculties believe that there is a steadily enhanced popular approval of (1) our pedagogical ideals, (2) our methods of scientific research, and (3) our linking the one with the other for the purpose of making scientific inquiry an incident part of man's education in preparation for an active, resourceful and creative life. The emphasis on scientific research is not wholly to train research men in the technical sense of cloistered laboratory discoveries, but the emphasis in the engineering schools is for the wholesome pedagogical influence which breeds an investigatory spirit. Engineering schools are in fact fitting a due proportion of men for scientific research of high order, but through their methods they are likewise fitting for the engineering industries men who are capable of ultimately assuming with distinction posts in scientific designing, manufacturing, salesmanship and administration according to the tastes and maturing experience of the individuals.

It also appears to us of the engineering schools that the direct incidence of our former students on the development of the industries has been for the good of the industries and for the people of the country. If the foregoing interpretations are correct, and we believe them to be, we have every reason to expect from the industries a fuller recognition than has yet been accorded. *Well-directed recognition will be approved by the people of this country, who (broadly speaking) are the consumers of industrial products and many of whom are stockholders. Well-considered support of the engineering schools by the industries is sentimentally as well as legally sound.*

Specifically and not exclusively, the engineering schools expect of industry many things, as industry on the other hand has come to expect many things of the engineering schools. Differences defined by territorial relations, industrial unities and scopes of individual schools arise to modify whatever claims of

expectation are put forward. However, I will risk some categorical suggestions. These are in somewhat dogmatic form but are expressed with a full sense of the friendly relations that exist between the engineering school faculties and leaders of industry, to an extent that is fast bringing us to see eye to eye on educational questions.

The engineering schools expect industry to recognize the duty of the schools (pertaining to them as educational institutions) of independence in thought, in subjects and methods of research, and in opinions. In return the faculties should recognize a duty to refrain from spreading inadequately founded opinions and from dogmatizing in controversial fields.

The engineering schools expect industry to recognize the importance of independent creative scientific research as part of the life of the faculties and students and to support it with contributions of money and counsel made to those schools that are adequately manned and equipped, to the end that additional knowledge may be disclosed out of which industry may forge new applications; and also to recognize the importance of such research as a pedagogical instrument in those schools that are manned and equipped to properly carry it on. Special investigations and researches for an industry that may be carried out in a school with free relation to students and with the understanding that the results may be published may be mutually useful to school and industry, even if a staff adequate for consecutive work on independent research is not available. Having routine tests made, and having special confidential researches carried on, in the engineering school laboratories, is a privilege that industry may claim and expect to be allowed, but this absorbs the intellectual power of members of the faculty and the time of equipment without recompense through student relations or publication of results; and this should be compensated for by money contributions which may be applied to independent research carried on in contact with well-advanced students.

The engineering schools expect large industrial establishments to pay more attention, in their own interest, to the articulation of recent graduates into the industrial work for which they are employed. With few exceptions the present practice is to fit these new employees into places requiring very limited needs, and to make no provision for such employees to gain (except by chance) an understanding of the accomplishments expected of them, thus leaving them "wallowing around" for months without light or leadership which often ends in atrophied resourcefulness and ambition. Supporting the use in the larger engineering schools of formal curricular enterprises led by engineers from industry, like the senior Colloquia in electrical engineering at the Massachusetts Institute of Technology, would fruitfully serve in improving this situation.

The engineering schools expect that the personnel problem of employing young men who are on the eve of completing formal study in the schools will be dealt with by the employing agents of the industries in a judicious and discriminating manner.

The engineering schools expect to clasp the hand of cooperation and not of domination where the employees of industry contact with engineering school faculties or students.

The engineering schools expect that leading men in industrial organizations will take cognizance personally of these needs to the end that the tenets may be vitalized; that dominant industries will recognize a special interest in supporting these tenets; and that associations of industries will also recognize a cooperative responsibility.

The engineering schools expect that industry will aid in laying before the public a fair statement of the public interest in continued industrial development and invention, and the need of maintaining independent research in the engineering schools in order that a stream of results may be available as raw material out of which to mould further industrial development and invention; to the end that the public may come to realize the propriety of industry making contributions of generous size to selected engineering schools for the support of independent research in those schools.

It is also reasonable to expect that men in industries will aid by directing to the engineering schools suitable young men who as students will persistently maintain high scholastic and character levels; who also possess at least incipiently appropriate qualities of personality and ambition, including fixedness of purpose.

The research relations between the engineering schools and the industries are being aided by the division of engineering and industrial research of the National Research Council. Industrial executives are giving increasing recognition to the value of research as a tool of modern industry. Economic pressure arising from competition is driving many industries into extended research activities as a protective and progressive measure. The increase from 500 definite industrial research laboratories in 1921 to over 1,500 in 1930 weaves the picture of this new economic trend. Small firms which are not prepared to create individual research centers for themselves can carry on by means of industrial fellowships in laboratory or-

ganizations maintained by educational institutions or government departments, or by means of research laboratories under the control of their own trade associations. On account of the development now in progress, the National Research Council Division referred to is appropriately turning its promotional efforts from "why do research" to "how do research," and plans are under consideration for bridging the gap between industry and educational institutions by means of conferences between leading institutions and industrial executives—also bringing the trade associations into the plan because they undoubtedly have a helpful influence for small companies.

The Division already has examples of such endeavors. Thus, in the welding field some ten leading institutions are undertaking investigational work of specific problems with coordination through an appropriate committee. Specimens needed in the investigational work are made up by industry under the exact conditions required by the laboratories. Special apparatus is supplied where needed. Some of the smaller companies, and even some of the larger ones, will find that for certain types of work the educational institutions will return more accomplishment for the research dollar than can be obtained in any other manner. But it must be remembered, in educational institutions and in industry, that mere projects of testing are not research, while it is the latter which brings progress and prosperity to industry.

The relation between any typical industry and the engineering schools can not be nationally uniform or nation-wide. Selectivity and discrimination (in the sense of recognition of fitness) are necessary to avoid waste of money and effort in cooperative relations which grow up between the industries and the engineering schools. In the engineering schools, we should aim to make our efforts at industrial cooperation primarily with those industries which have establishments within nearby territory and whose interests lie principally within the range of our individual school curricula and equipment, but the sources of our students may be world-wide and the employment of men who take our degrees may be nationally spread. The engineering schools expect individual industries to give their cooperation primarily for their own welfare, but additionally because it is for the best interest of processes of higher education which associate generally with the industrial welfare of the country. The engineering faculties devote their lives to work of beneficial interest to the industries and it is reasonable for the faculties to expect constructive cooperation and aid from the industries.

OBITUARY

WILLIAM DILLER MATTHEW, PALEONTOLOGIST

(1871–1930)

THE death of William Diller Matthew on September 24, 1930, cut short at the height of his career a man who had contributed immensely to the science of paleontology, one who realized the value of this science for the philosophy and art of human living and who was in the midst of a sustained and highly successful effort to open wide its broad fields, especially to great numbers of his own well-trained students.

In 1894 Matthew was a red-cheeked Canadian youth in the department of geology at Columbia. His main interests at that time were in crystallography, in trilobites and in the structure of the intrusive and effusive rocks of his native country around St. John, New Brunswick. His father, George F. Matthew, was an amateur geologist in the best sense, since he was a recognized authority on the geology, fossil plants and early amphibian footprints of New Brunswick. His mother successfully reared a large or "old-fashioned" family and imparted to all her children her irrepressible cheer and good humor, as well as her high ideals of service. Fire consumed the elder Matthew's collection of fossils and his scientific library; but he set to work to build them up again. The son was a young man of almost Spartan simplicity of life: frugal and self-denying but early learning to achieve excellent results with slender resources.

With such a background the young Matthew, after obtaining his doctorate at Columbia in 1895, came to the American Museum of Natural History at the invitation of Professor Henry Fairfield Osborn to be a scientific assistant in the then young department of vertebrate paleontology. His first big task was to go down to Philadelphia to catalogue and pack up for shipment the great private collection of vertebrate fossils which had been amassed by Professor E. D. Cope, and had recently been sold to the American Museum. In this way Matthew gained his first extensive contact with Cope's life-work and collection. During the next thirty-five years it was his lot to catalogue and identify tens of thousands of vertebrate fossils for the ever-growing collections of which the Cope collection was the foundation. More cautious than Cope and far more critical, with the advantage of great stores of additional material, he corrected, revised and extended Cope's work in many