ORIGINAL INVESTIGATIONS BY ENGINEERING SCHOOLS A DUTY TO THE PUBLIC AND TO THE PROFESSION.

THE function of the modern university includes much more than the mere imparting of instruction to its students. In a newly recognized, important sense, the entire public must be considered university students, and by frequent publications, addressed to different classes of people, by extension lectures and possibly by correspondence instruction, the modern university must seek to educate this greater student body. Besides this no university, no department even, of a university can be considered to be doing living, vital work, unless in addition to its routine of instruction it is carrying on original investigations. Otherwise its work will be merely mechanical. No student can be properly educated without *bringing him* into such close contact with veiled truth that he feels the very throb of her pulse, and receives direct from her the inspiration to become himself a searcher after truth.

It is the object of this paper to make a plea that the function of the modern technical school should be, in its particular field, closely similar to that of the university, as outlined above. The author believes that in addition to educating engineers, the technical school should, by special courses supplying special equipment, train leaders for all the industrial and commercial work of modern civilization. More than this, he believes that by the publication and distribution of frequent bulletins on technical, industrial and commercial subjects, by its faculty taking part in the meetings and conventions of the various technical, industrial and commercial interests and societies, and eventually perhaps by systematic extension lectures and correspondence courses, the technical school should seek to educate the industrial and commercial public in the applications of science to their work.

It is the special object of this paper, however, to make a plea for systematic, original investigation in technical schools. The necessity for work along this line has been so great and so plainly apparent that a great deal has already been accomplished. The term *original investigation* should be understood to include much besides experimental research. The writing of good technical books, for example, involves a large amount of original study and research, for such books should never be mere compilations. In the columns of one of our principal technical journals 73 technical books were reviewed during the year 1899, and 25 of these were written by professors in engineering schools. There is not a single technical journal, and perhaps not an important technical society publication in the country to whose columns frequent contributions are not made by engineering educators. The current of progress of technical education is sweeping engineering professors farther and farther away from the old exclusive devotion to class room instruction, and more and more bearing them into active participation in the daily outside work of their professions.

The development of original investigation at technical schools has been especially rapid in late years along the line of experimental research. The modern methods of instruction require extensive and expensive laboratory equipment, which is also available for experimental research. The multitude of subjects pressingly needing such research is so great that energetic engineering instructors are naturally led into experimental investigations. Frequent reports of the results of such work are seen in the technical society proceedings. Also most engineering schools maintain regular publications, in which the results of many experimental investigations by both faculty and undergraduates are reported. It is impossible to mention here many of the

numerous important experimental investigations which have been made at American engineering schools, but attention will be called to two cases: first, all are familiar with the important work in connection with paving brick which has been done at the universities of Ohio and Illinois, and which has been accepted as authoritative by both engineers and manufacturers; second, the great hydraulic laboratory at Cornell has required the most lavish expenditure of money devoted exclusively to preparation for experimental research in a single line of work yet seen at an American technical school.

The great value of such investigations to the engineering profession is readily apparent. The value in connection with the instruction of engineering students is also great. Bringing the student into personal contact with the progress of such investigations, carried on by his instructors, does much to awaken in him professional enthusiasm and an ambition to become himself a contributor in the future to the common stock of technical knowledge. The student is led to see that there is much more in engineering education than the mere absorption of knowledge, and much more to engineering practice than the mere routine of carrying out pre-established methods. He sees that he must learn to think for himself in his future work, and to investigate for himself the problems which he will encounter. In the simpler work connected with experimental investigations bright, reliable students can often be employed to advantage. This is especially true in work suited to thesis investigations. The author knows of no more valuable training a student can have than to carry out successfully an experimental research, overcoming all the unforseen difficulties sure to be encountered, and at the end completely digesting the results obtained. The author believes, however, that all experimental work by undergraduates should be done under very close supervision by a skilled instructor. Much valuable thesis work has been done in this way at engineering schools.

While much has already been accomplished in orginal investigations at American technical schools, such work has heretofore, with few important exceptions, been carried on spasmodically, with no systematic pre-arranged plan. The author believes that this should now be changed, and that wherever possible technical schools should deliberately plan for investigations as a part of their regular work. Each school should decide what lines of work are best suited to its location and circumstances. Proper space and equipment should be provided. The faculty should be made large enough to permit the necessary time to be devoted to the work. Funds should be provided to meet the expenses. Arrangements should be made for the regular publication of the results.

Investigations which can be carried out at engineering schools are of two kinds: first, those mainly of professional interest and value; and second, investigations whose results have a considerable commercial, industrial and public, as well as professional value.

As to investigations of the first kind it may be said that the practicing engineer frequently encounters problems which ought to be investigated experimentally, but it is seldom the case that he can command the necessary laboratory equipment or the time for such work, or induce his employers to furnish the necessary funds. Such problems should be referred to the schools and there investigated. Thus the schools may perform their duty to the profession, and may ask in return, as they do even now, that the practicing expert shall give them the benefit of his experience, in non-resident lecture courses. There will result that co-operation and close association between the engineering educator and the practicing

engineer which is so essential to the best interests of the profession.

As regards investigations having a commercial and industrial value, attention may be called to the prominence which has recently been given to discussion of the value of scientific technical training for the leaders and workers in our manufacturing and commercial industries. The mono-technic and the trade schools of Germany have been held up as models for the world. The author believes that, under American conditions, the first decisive step towards solving this problem should be taken at the technical schools, especially the state colleges and state universities which are the beneficiaries of the Morrill government aid laws. The nearest approach now made to systematic technical education for one industry in this country is seen at our agricultural schools and experiment stations. At the best of these schools not only are the students given a thorough scientific education and training for leaders in agricultural work, but also extensive scientific agricultural experiments and investigations are continually being carried on. The results are systematically published and distributed in bulletins. The faculties attend the regular meetings of the institutes and conventions of agricultural interests, and there inform the public concerning the results of the college work and the principles of scientific agriculture. The author believes that similar training and aid should be given by our technical schools to American manufacturing, commercial and other industrial interests. At least, investigations helpful to these interests should be undertaken, and the results systematically published. The school which will undertake such work will receive hearty support from the industrial interests of the country, and means for carrying on the work will not be lacking.

In a new and rapidly developing country like ours there are many yet untouched resources. It would greatly accelerate the development of these if scientific investigations of their possibilities were made by the technical schools. For example, in the case of quarries, deposits of cement materials and clay deposits, both the raw materials and the finished products can be carefully tested and their qualities published. Again, in processes of manufacture, the effect of different processes in the quality of the product can be studied. New applications of botany, chemistry and physics to manufacturing processes can be found.

In fact the subjects suitable for investigation at engineering schools are very numerous, and no attempt will be made here to give an exhaustive list. The following may be mentioned:

Theoretical Mechanics.—Experimental studies, accompanied by mathematical investigations of the theory, may be made of such problems as the actual pressure against retaining walls, the theory of concrete and steel combinations, problems in hydraulics, and many others.

Materials of Construction.—The methods for testing the materials of construction need extensive experimental investigation, and should be completely standardized. The properties of both long used and of new materials may be studied and made known. Standard specifications may be prepared for the properties developed by the standard tests.

Sewage Disposal and Water Supply.—The methods of analysis of sewage and water need careful experimental study to determine the best methods and the interpretation to be placed on the results. Analyses of sewage and water can be made for the municipalities and corporations of the state. Many sewage and water purification problems can be studied experimentally, and systematic examinations and reports can be made of existing plants in the State

Steam and Electrical Engineering.—Laboratories can be provided for tests of different kinds of machinery, and for the experimental investigation of problems of correct design. Efficiency tests of outside plants can be made.

Mining Engineering.—Geological studies of deposits of building stones, cement materials, clays, fuels and ores can be made, and the qualities tested.

Manufacturing.—Applications of science to manufacturing and the comparative values of different processes can be studied, as already mentioned. With the aid of statistics, political economy as related to manufacturing, can be studied.

Transportation.—Good roads and road materials in the State can be studied. Laboratories can be established, fitted for tests of transportation machinery. The political economy of transportation problems can be studied.

The author does not claim that any one school should undertake all of the above lines of work. On the contrary, the work undertaken by any one school should be restricted to what it can carry on for a long period of time, and so extensively and thoroughly that the results shall be conclusive. Particular schools would naturally become authorities in particular lines, and their work would not be duplicated by others, although many lines of work would need to be carried on by several schools, because local conditions differ.

As an illustration of a modest and imperfect beginning of such work, made under many difficulties, the author would say that at the school with which he is connected the following lines of work are now under way:

The college has a sewage disposal plant which purifies about 50,000 gallons per day. Regular analyses in connection with this plant are made, complete records are kept, and investigations with the plant are under way. Special tests with smaller apparatus are planned. The college has just co-operated with a neighboring city, securing and publishing at the expense of the city the preliminary data for the design of a purification plant for 2,000,000 gallons of sewage per day. The college proposes to examine and report upon sewage disposal plants as fast as they are installed in the State. In connection with the clay interests of the State quite a large number of plants have been visited, samples of clay and brick secured for tests, the clays and processes of manufacture studied, and several thousand tests are under way. Samples of new clay deposits are frequently received, analyzed and reported upon. An appropriation has been made for starting a ceramic laboratory, modelled after the one at the Ohio State University. A set of tests of the heating properties of the coals of the State is under way. Tests of the building and paving materials of the State are being made, and extensive statistics of brick paving collected. Special investigations of timely interest are taken up as opportunity permits. It is proposed to extend this work.

It is obvious that if the extension of the work of the modern technical school advocated in this paper could be made to the utmost possible extent, the status of the technical school would be greatly changed from what it now is. No longer could the schools be considered as existing simply for the benefit of its students. All practicing engineers would equally consider it theirs, and the great industrial and commercial interests of the country would consider it theirs. Such a technical school would be one of the most potent agencies imaginable for the betterment of the welfare of the people, and for the progress of modern civilization.

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