

# INDEPENDENT LABORATORIES IN THE ENGINEERING INDUSTRIES.\*

BY

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THE importance of laboratory work in connection with our national industries is coming more and more to be recognized, and there is no little discussion at the present time of suitable ways and means for promoting it. With the sharpened competition which must ensue at the close of the war which is now paralyzing the peaceful industries of the world, any and all means for increasing our industrial efficiency will be considered with a seriousness which in the easy-going times of the past has not been accorded to them.

Our great manufacturing organizations are for the most part quite awake to the fact that laboratory testing and research are necessary and indispensable adjuncts to the growth and development of their industries. They realize that it is to the laboratory that they must look for radical or fundamental advances in the materials, methods and processes of production. They have established splendid laboratories and have attracted to them some of the greatest scientific men of the country. The product of these laboratories has been of enormous value—a value which cannot be measured in money, for it includes engineering and scientific discoveries which become the permanent possession of the human race and add to the prosperity and happiness of all future generations.

The manufacturers of smaller resources do not, however, make a correspondingly large use of laboratory assistance. This may be ascribed to two causes: first, that they are not so fully aware of their own need for laboratory assistance and of the possibilities of laboratory work in increasing their efficiency, bettering their product and broadening their scope; and second, because of practical difficulties in securing such laboratory facilities.

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\*Communicated by the Author.

ties as correspond to their needs. It is with the latter phase of the situation that this paper is intended primarily to deal.

Laboratory or research work is commonly divided into two classes, both of which are important in connection with our national industries. First, there is the work in pure or academic science—the work primarily of the university. Second, there is the work in applied science, or in industrial research. Dr. J. J. Carty<sup>1</sup> in his address as President of the American Institute of Electrical Engineers, has very clearly and very aptly drawn the distinction between research in pure and in applied science when he said that it lies neither in the subject matter, which may be identical, nor in the methods, which may be the same, but in the motive. To quote his words:

“Industrial research is always conducted with the purpose of accomplishing some utilitarian end. Pure scientific research is conducted with a philosophic purpose, for the discovery of truth, and for the advancement of the boundaries of human knowledge.

“The investigator in pure science may be likened to the explorer who discovers new continents or islands or hitherto unknown territory. He is continually seeking to extend the boundaries of knowledge.

“The investigator in industrial research may be compared to the pioneers who survey the newly discovered territory in the endeavor to locate its mineral resources, determine the extent of its forests, and the location of its arable land, and who in other ways precede the settlers and prepare for their occupation of the new country.”

Evidently the industrialist who, to carry the analogy further, may be likened to the settler in the new territory, is dependent upon both classes of investigator; on the investigator in pure science because it is he who indicates the existence of a field heretofore unknown; on the industrial investigator because it is he who discovered the commercial possibilities which the field contains.

The organization which is pre-eminently fitted to carry on the primary work of pure scientific investigation is the university. It is to the university that we must look to discover and to foster the men having those rare and peculiar gifts of imagination, of transcendent patience, of unselfish devotion, which go to make up the explorer into the unknown regions for

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<sup>1</sup> Carty, Proc. A. I. E. E., vol. xxxv, p. 1411, Oct., 1916.

the extension of physical and chemical science. It is the university which must furnish these men the surroundings and the facilities which are required for the prosecution of their work.

For the adequate pursuit of industrial research work, however, it is necessary to look to organizations constituted differently from the university. Industrial research having as its end the accomplishment of a definite result of commercial value accruing primarily only to the promoter of the work, it is evident that an institution organized like the university primarily for an educational purpose, and supported largely by endowments or by public funds, cannot justly devote any considerable portion of its energy or of its resources to any purpose which is not for the benefit of the public at large. The technical schools in this respect are in the same class with the universities, with the important exception that a technical school is in general better situated for the conduct of industrial research work than is the university from the fact that its training is along industrial lines. Hence we find that many of the great industrial corporations in this country have, as has been said, met their own needs by establishing their own private industrial laboratories. For the industries at large, however, this affords no adequate solution of the laboratory problem, for it does not apply to the multitude of concerns, individually smaller than the great corporations and unable each by itself to support economically and efficiently an adequate laboratory, but in the aggregate of enormous industrial importance. The importance of laboratory work to the smaller concerns is relatively just as great as to the larger ones, and the problem is, the best means of supplying their needs in this particular.

One possible solution is for the smaller manufacturer to take his laboratory problems to a technical school for solution. This plan, while it may work out admirably in many cases, is open to the objection which has been mentioned above, namely, that the funds of the institution, being given for a public purpose, should not be diverted to private ends. However, it may be urged against this that it is to the advantage of the technical school to take on a certain amount of industrial work, not only in research but also in testing. Such work necessarily brings both instructors and students into contact with certain practical problems of the outside industrial world, a world of which they know much in theory but too often but little in practice. The effect of this

contact cannot but be broadening and helpful to the technical school and to its students, and if this advantage is sufficiently substantial, the theoretical disadvantage of diverting the attention and the resources of the institution to a limited extent to matters which are particularly the affair of private outside individuals or corporations is more than counterbalanced. Added to this advantage to the technical school are certain others, among which may be mentioned that incidentally the frequently inadequate salaries of the body of instruction in the technical school are to some extent augmented and the instructors thereby put into a position more nearly in accord with the demands which are made upon them. To the industrial concern a recourse to the laboratory of a technical school may offer the advantage of furnishing a service for a smaller expenditure than would be necessary if all of the overhead and incidental charges were included, which under similar circumstances a commercial organization would have to make.

As against the advantages so outlined there are certain disadvantages which must be given careful consideration and due weight. We have noted that taking on a piece of industrial work has the effect of bringing instructors and students into contact with practical industrial problems and thereby broadens their vision and increases their usefulness. To the industrialist, however who has a problem to solve, the very lack of contact with the actualities of practice very greatly lessens the value of the technical school as an organization for the accomplishment of his purpose. Every technical problem is surrounded by limitations and special conditions which may not from an academic standpoint appear to be of controlling importance, but which if not given their practical weight render any solution nugatory. Considerations of cost, of the intellectual and psychological limitations of workmen, of transportation, or market conditions, of company policy, of technical and commercial usage in the field—any or all of them may have their influence on the result. The technical school men, if less in touch with practice, are evidently at a disadvantage in the solution of problems involving these elements. The technical school, being organized and equipped for purposes of education and not for purposes of testing or industrial research, is frequently at a disadvantage on account of the limitations of its laboratory equipment, the amount of power, etc., available, and on account of

the lack of a business or technical organization especially designed to prosecute with directness, accuracy and engineering common-sense, industrial problems which it never was designed to handle. It must be remembered that while many discoveries are made by laboratory experiments on a small scale, many of these are not applicable to industrial exploitation for the reason that elements which in small-scale experimentation are of negligible importance, often become controlling factors when the scale is changed to correspond to practical production. A chemist in his laboratory may effectually close a flask with a cork; a similar procedure does not apply at all to a spouting oil well. He may evaporate to dryness a dilute solution for the purpose of recovering a small residue and never once think of the gas which he uses in the process. If he were dealing, however, with the same operation on a scale ten thousand times as big, the matter of fuel and of containing vessel might offer insuperable obstacles to commercial success. Small-scale experimentation teaches but little regarding the proper design of a switch to open a high-tension power circuit. Hence apparatus which is quite adequate for the small-scale work of the laboratory of instruction may be entirely inadequate when experiments are required looking toward the industrial application of a process.

In speaking of this feature of industrial work in educational institutions, Dr. Steinmetz <sup>2</sup> in a recent address said:

“Unfortunately this limitation of research work in accordance with the available facilities is not always realized, and especially educational institutions not infrequently attempt research work, for which industrial laboratories are far better fitted, while research work for which the educational institution is well fitted, which the industry needs but cannot economically undertake, is left undone.”

Prof. James Swinburne <sup>3</sup> in a lecture on Science and Industry, delivered very recently at Kings College, has pointed out that the instructor in technology tends as times goes on to be less and less in touch with practical conditions and more of an academic scientist. This is for the reason that in general only those who have less taste for engaging in the practical work of industry are likely to take up the teaching profession, and their own successors

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<sup>2</sup> JOURNAL OF THE FRANKLIN INSTITUTE, vol. 182, p. 711, December, 1916.

<sup>3</sup> *The Electrician*, London, vol. lxxviii, p. 182, November, 1916.

are as a general thing the less practical ones of their own students. The academic scientist, on the other hand, is a master of his subject, for his science, like himself, is academic, and in his own field he is pre-eminent. Thus the tendency of the technologist to become academic is a tendency for him to follow his own proper bent and to employ his energies in the direction in which they will be most effective.

Since to refer the problems of the industry to the technical schools for investigation does not offer a satisfactory solution of the problem, some other way out must be sought. This may be found along the lines indicated by Dr. Carty when he said:

"One of these is for the manufacturer to take his problem to one of the industrial research laboratories already established for the purpose of serving those who cannot afford a laboratory of their own. Other manufacturers doing the same, the financial encouragement received would enable the laboratories to extend and improve their facilities so that each of the small manufacturers who patronizes them would in course of time have the benefit of an institution similar to those maintained by our largest industrial concerns.

"Thus in accordance with the law of supply and demand, the small manufacturer may obtain the benefits of industrial research in the highest degree and the burden upon each manufacturer would be only in accordance with the use he made of it, and the entire cost of the laboratories would thus be borne by the industries as a whole, where the charge properly belongs."

Thus to the independent laboratory is assigned an important place in the engineering industries as providing for the smaller manufacturer laboratory facilities comparable with those enjoyed by some of the great corporations. To fulfil properly these functions the independent laboratory must be adequately supported, properly manned and abundantly equipped. Its staff must be organized on broad lines. Its engineers must be familiar with the practical and commercial features, as well as the technical details, of the work which they encounter. It must include physicists and chemists accustomed to look at the fundamental features of the problems presented and to bring to bear upon their solution the methods and the point of view which are inculcated in the university laboratories of research, for the application of fundamental scientific principles to the solution of the problems of industry

underlies all true industrial research. The fees charged by such a laboratory must be adequate to cover not only all expenses, but to yield a sufficient profit as well, for:

“ Unless industrial research abundantly supports itself, it will have failed of its purpose.”

In return for the fees so paid it must deal with its clients in a highly confidential manner, conserving to them individually all of the results of the work for which they are paying. It must be prepared to turn over to its clients the inventions and patents which are the direct outcome of any specific piece of work. It must organize its work efficiently, so that its costs are as low as is consistent with good work and so that the results are obtained without undue delay. As to equipment, this undoubtedly must be large. The variety of problems which a laboratory of this sort will have brought to it will be of such scope that a great variety of instruments for measuring and for manipulation must be at hand. A very large supply of electrical power is an absolute requisite. These conditions interpose serious obstacles in the way of the establishment of laboratories of this character. Unless the laboratory is organized through the coöperative efforts of a considerable number of industrial corporations operating in the same or in similar fields, a difficulty is sure to be encountered in insuring beforehand its proper support. To some extent a laboratory of this sort must from its very inception possess an equipment representing a very considerable investment. Unless therefore the financial support is insured beforehand, no little faith is required on the part of those investing their money in it. When, however, it has been possible to establish a laboratory of this character, the scope of its work may be very large. It may, and should, include not only industrial research proper, but ordinary and routine testing, such as is required not only by manufacturing concerns, but also by consulting engineers and others. It should be prepared to make acceptance tests of manufactured articles on behalf of purchasers and a considerable part of its activities may lie in this direction. It should offer facilities to engineers, inventors and other would-be experimenters to carry on laboratory work of their own under its roof, and should make available to them all its own facilities. In carrying out work of this great scope in an adequate and proper manner the independent laboratory will find itself side by side with the technical

school as one of the potent factors of industrial progress. The staff of such a laboratory will become increasingly efficient through the practical solution of problems of many kinds. The apparatus and other equipment will necessarily take on a diversified character such that new and unusual problems presented can be undertaken without the purchase or construction of special apparatus. As compared with under-equipped and insufficiently manned laboratories which with a most laudable spirit individual manufacturers may establish for their own use, independent laboratories, supported by formal or informal coöperation, should be far more efficient both as regards the cost of maintenance, the character and extent of the equipment, and as to the practical results to the industries, because of the product of the researches conducted therein. In the last analysis the availability and utility of such laboratories depend on the amount of material support which the industrial world is willing to accord to them.

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**A Method of Comparing Automobile Performance.** W. T. FISHLEIGH. *Society of Automobile Engineers' Bulletin*, vol. xi, No. 2, November, 1916.)—The problem of analyzing automobile performance is not a new one and much has been written and argued upon the subject. The demand is widespread for a standard interpretation for performance and a method of determining it. Numerous formulas have been proposed. In most cases these are efficiency formulas, designed for estimating from certain known dimensions the probable performance or performance factors. In no case are all these factors included that seem critical in performance; in several cases serious inaccuracies can be pointed out when their application to actual road performance is attempted.

Automobile performance should be determined by actual tests, and *speed range, acceleration, fuel economy and riding comfort* are the factors for such determination. The first three of these factors are susceptible of measurement by accurate tests and the product of such factors would result in a satisfactory criticism of performance. It has been pointed out, however, that in taking the product, the identity of each one is entirely lost, and for purposes of comparison the limits rather than the maximum of these three factors should be separately considered as the three dimensions of car performance. The factor of riding comfort is one that scarcely admits of definite numerical expression.