APPLIED SCIENCE IN YORKSHIRE*

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WE shall exclude from consideration in this paper the effect of applied science on industrial prosperity, whether in particular industries or in general. Admittedly the promotion of applied science from the educational point of view cannot in fact be separated from the promotion of industrial prosperity. But the discussion of each presents a different problem, and the value of applied science as a type of investigation is not to be judged exclusively by the wealth which it has brought to Yorkshire.

We must also exclude all reference to the investigations and the results achieved in the various applied sciences carried on in the province. The statement of these would take many volumes and many experts to expound.

First of all, we must try to clear the ground by explaining shortly what applied science means. There is still a certain amount of misunderstanding on this subject, especially on the part of those who draw a hard and fast line between pure and applied science, or by those who tend to regard applied science as of subordinate scientific interest and importance. There are some who treat applied science with a certain disparagement, as being an attempt to adapt science to commercial purposes, a means of increasing wealth rather than of increasing knowledge. This attitude of mind is not perhaps so widespread as it used to be, but it still exists in this country. Institutions such as the younger universities, which from the first seriously took up investigations which fall within the scope of applied science, have on that account been held to have derogated from the traditional university conception. Certainly up to recent years in this country, no such problems were considered to deserve the attention of the academic mind. It was in fact for long held to be a recommendation and a merit that universities taught and investigated only subjects which could be studied in order to acquire knowledge for its own sake, and were useless otherwise except as promoting mental discipline. It is instructive to observe that this narrow and indefensible outlook on knowledge is changing, and that the older universities are now taking a prominent and leading part in the advancement of applied

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science. We have only to recall in this connection the important investigations carried on in both the older universities in the department of agriculture, and the work done in Cambridge to solve the difficult practical problems of cold storage. The institution, a few years ago, of the Department of Scientific and Industrial Research with its corollary, the setting up of the Industrial Research Associations, is rapidly modifying and will in time completely transform the former attitude of the public and academic mind to applied science. When the history of universities in this country comes to be written, it will be found that not the least of the contributions made by the younger universities to the development of academic life in England is that they led the way in recognizing the scientific value and interest of applied science. In this movement the Yorkshire universities have played an important part.

Applied science is neither more nor less than an investigation in the laboratory of the processes which are involved in the adaptation of nature to the service of society in one form or another—a purpose which is surely eminently important and desirable. Some of these processes have been carried on empirically and with relative success for generations, to the great advantage of mankind. A large amount of experience has been accumulated and handed on by tradition, custom and instruction; but such experience has not been critically examined in the light of and by means of scientific method and resources. So far as rules have been arrived at in this way, the experience acquired rests on what we may call rule of thumb. The purpose of applied science is to substitute the rule of scientific law for the rule of thumb. In other cases the laboratory examination of nature's processes and material may lead and has led to the discovery of ways and means of adapting nature to man's service in directions which have not been thought of in the past. In these cases the knowledge of the laws discovered by science precedes the adaptation of nature's resources to man's use. New industries and manufactures may arise as the result of the antecedent work of the scientist. Even here it must not be assumed that the application of science ceases to be science when the science is applied. The application consists in carrying out in detail the general laws discovered by science; and this in principle is in no way different from the process of verification by practical test which is an essential characteristic of scientific method. In other words, the application of science is a process of science as much as the discovery of the laws which are applied for man's service. Whether, therefore, the process of using nature for man's ends precedes investigation by the scientist, or scientific investigation precedes

and gives rise to the application of nature to man's ends, is merely a matter of history and does not affect the meaning of applied science.

Applied science is thus quite distinct from the industrial and commercial development of the results of scientific investigation. This development depends on other considerations:—whether the capital is available to commercialize the results, whether anyone has the imagination and resourcefulness to produce an article which will appeal to the public, or whether the adaptation of the results for the use of man is economically profitable at a given time. Faraday's discovery of magnetic induction was of immense potential service to man, but it required time and genius of another order than his to foresee the ways and means to make it available for man's convenience.

Applied science differs from pure science not by presenting a less difficult problem or by being less scientific than pure science. The sole differentia is that in the former case the results can promote man's desire to bend nature to the service of the social life of man, while in the latter there is no such reference, at least directly or in the mind of the investigator while carrying on his investigation. The one aims at the active control of nature, the other at the reflective comprehension of nature. Both are essential to the fulfilment of man's life, and equally important ways of manifesting the supremacy of mind over nature on which civilization rests. Neither is subordinate to the other, and as experience shows they reciprocally assist one another, just as any science may produce results of value to another science. Sometimes we find that discoveries in pure science lead to new developments in applied science; sometimes achievements in applied science give suggestions for further investigation in pure science. Indeed there is no pure science, however apparently remote from social welfare, which may not in the long run promote the aim of applied science.

Apart from the fact that it is important to make clear once for all the significance of applied science, the foregoing statement has a direct bearing on the subject with which we have to deal. For the development of applied science in Yorkshire has been governed by the recognition that effective control over nature's processes, whether carried on in established industries or not, can be secured only by scientific investigation in the strictest sense. In the universities of Yorkshire in particular, applied science and pure science departments have been established from the first alongside one another. This has not been a mere accident, but a settled policy which, for the reasons given, must be considered tc

be as sound in principle as it has been fruitful in its results, both to the students of science and to those engaged in scientific investigation. And the same policy has been adopted in the case of the higher technical colleges in Yorkshire, for example, those of Bradford and Huddersfield, where good work has been done not only on behalf of applied science but also in pure science.

No doubt in the early stages of the history of applied science in Yorkshire primary importance was attached to the practical applications of science to technical processes rather than to pure science. The practical mind of Yorkshire was inclined in the first instance to appreciate science for its value in furthering an intelligent interest in the productive industries of the area. This was but natural, and not unreasonable. And since those concerned for the promotion of industrial welfare by means of science were, in general, not themselves trained in science, but had heard of or foreseen its value, it was perhaps inevitable that the conception of applied science was understood in a comparatively narrow sense, as investigation and instruction in the craft side of industry and in the scientific subjects which seemed relevant thereto. The craft side is certainly an essential aspect of applied science, and must always be so if science is to be applied at all. It was only later and rather slowly that it was realized that this aspect merely sets the problem of applied science, and that the understanding of the craft does not provide a solution of the questions which industrial processes raise. Still, even this humble beginning gave the start to what has proved a vast scientific undertaking.

Historically, the beginning lies in the work of the mechanics' institutes. Apparently the first of such institutes in England was established in Birmingham, though the conception of this type of institution originated in the Andersonian Institution in Glasgow and was due to the inspiration of Dr. Birkbeck, early in the first decade of the 19th century. A number of these institutes were started in the larger towns in Yorkshire at different dates in the course of the century, that in Leeds being set up as early as 1824. In 1832 a mechanics' institute was established in Bradford, where it has this year celebrated with justifiable pride its centenary. The purpose of these institutes is indicated by their name, and they were necessarily restricted in the scope of their operations. But they were the first attempt to satisfy a new demand of much greater significance than was at first appreciated—the demand to acquire a knowledge of the sciences which had a bearing on industry. The institutes were voluntary and self-constituted associations of individuals, rather of the nature of clubs for more or less popular lectures.

The next stage was the establishment of the technical college. This differed from the mechanics' institute in several important respects. It was a public institution; instruction was systematically carried out in specific subjects bearing on local crafts, and in some sciences; and the education supplied was tested by examination. The most important influences which led to the setting up of technical colleges were the Science and Arts Department in Kensington, the City and Guild Institutes of London, the work of the Normal School of Science of which for a time Huxley was Dean, and the Report of the Royal Commission on Technical Education in 1883. These influences affected Yorkshire as well as other parts of England. In the latter half of the century technical colleges arose in the larger industrial cities in the Yorkshire area.

The third stage appears with the institution of the Yorkshire College in Leeds and the University College in Sheffield (formed by the Union of the Firth College and the Technical School in 1899), which not only gave instruction at a higher level than was to be found in the technical colleges, but for the first time undertook research in some of the applied sciences, and contained pure science departments conducting research and providing instruction up to degree standard.

A further stage was reached when, after a generation of work and the development of financial resources, these two colleges assumed at the beginning of the present century university status, the University of Leeds being founded in 1904, and the University of Sheffield in 1905. This was a great step forward in the history of applied science in Yorkshire. They both incorporated technological departments within the university curriculum. They thereby gave applied science a distinctive place among university studies, and brought a scientific spirit to bear on problems which in the technical colleges had been treated mainly from the craft point of view. The method of incorporating technology within the university differed, however, in the two universities. The University of Leeds instituted, at the start of its career, a Faculty of Technology on the same footing as other Faculties, and placed within it all the applied sciences: the University of Sheffield formed two Faculties of applied science, a Faculty of Engineering and a Faculty of Metallurgy. The difference of procedure, however, implies merely a difference of view regarding the nature and function of a Faculty in a university. It may be remarked in passing that of the seven younger universities established since the beginning of the century in England, the University of Leeds alone has constituted a Faculty of Technology within the university as such.

The only other university with a Faculty of Technology, that of Manchester, has recognized for this purpose the technical college of the city.

The establishment of the Universities of Leeds and Sheffield, which represents the culminating point in the institutional development of applied science in Yorkshire, created new standards and a new outlook in the conception of applied science and its value for industry. Hitherto applied science in the widest sense had been restricted to the communication of information on and the study of the technique of industrial processes carried on in the area, with some instruction of a rather elementary kind in certain of the pure sciences. The aim was to train or provide craftsmen with an intelligent appreciation of the rules and operations of their respective crafts, so that there might be in industry more competent and efficient workmen. With the advent of the universities, and the spirit of detached scientific enquiry which inspires university work, applied science was able to become the critic and investigator of traditional industrial processes and methods, and to place the resources of a wider scientific outlook and knowledge at the service of applied science. This raised instruction in applied science to a higher intellectual level. It could not be merely the communication of traditional knowledge acquired by experience in industry; its aim was not simply to confirm but to transform existing practice in industry by training whole-time students in scientific principles and by promoting scientific investigation of industrial processes. This could not but be the ultimate advantage of industry, though the effects might not be seen for some time.

The prosecution of applied science at this higher level had a further important consequence; it suggested and indeed created a graded system of technical training and education, with craft instruction in its various forms at one end of the scale and specialized scientific investigation into industrial processes at the other. The first could be appropriately taken over by the technical colleges, the second by the universities. And, looked at broadly, this is what has occurred in Yorkshire. The universities to begin with, but to a less extent in the course of time, undertook a certain amount of craft instruction more especially to evening students. In some technological departments such instruction is still given. But the tendency undoubtedly is to delegate such sub-university work to technical colleges as such.[1] Carried on in universities it is at once uneconomical and deflects the university from its main purpose, which is to increase knowledge by investigation and com-

1. In Sheffield, the sub-university work of the technical college type is carried on in the same building as the university work.

municate the highest knowledge available to students qualified to appreciate it. No doubt applied science necessarily implies the practical application of scientific ideas through the technique of a craft. But in a university the craft operation should be subordinate to and an illustration of the scientific principles with which the university is mainly concerned. On the other hand, craft instruction is a matter of degree. There is elementary craft instruction, and higher craft instruction. In the case of the latter it is not possible to give the necessary training without a knowledge of scientific principles, and a staff qualified to communicate such knowledge is often equally qualified to conduct scientific research, if time and resources are available. There are such higher technical colleges in Yorkshire, the most efficient being those of Bradford and Huddersfield, where research has been done by some members of the staff in spite of the amount of time given by them to technical instruction, and where scientific teaching on a level up to university degree standard can also be obtained. There is thus at points a certain overlap, perhaps inevitable, between the work of the technical colleges and the universities. But the main distinction is clear between the purposes of the two types of institutions occupied with applied science. The primary business of the technical college is to provide craft instruction at a lower or a higher level, with higher scientific instruction and research occupying relatively a second place in the work of the college; the main purpose of the university is to provide higher teaching in science and to carry on scientific investigations in applied science, with technical instruction occupying relatively a secondary place in its work.

The increased recognition of the value of technical instruction, even at its lower levels, has led to the recognition of the importance of providing such instruction as extensively as possible to those who are to proceed to industry. This is necessary to make completely effective the application of intelligence and knowledge to industry: the lower technical craftsman is necessary to appreciate the work of the higher, and to co-operate with him. Hence the increasing importance attached to the work of the so-called junior technical college. This point has secured much attention from the Yorkshire Council for Further Education, whose aim has also been to endeavour to bring about a due and much needed co-ordination between technical colleges and technical instruction generally in Yorkshire. The consideration of the work of this Council is a subject which will come before the Education Section of the British Association meeting at another stage, and does not

concern us in this paper. We will content ourselves in passing to remark that the Council has an important part to play in Yorkshire if it can accomplish its two main objects:—the extension of the scope of technical education, especially by increasing the scope of junior technical colleges, or junior branches of technical colleges; and the much needed systematic co-ordination of technical colleges with one another and with the university Departments of Technology.

In addition to and apart from the institutional development of applied science in Yorkshire, which has been described in outline, there have come into existence since the war, and perhaps largely in consequence of the war, the new types of organization for bringing science to bear on industry already referred to:—the Department of Scientific and Industrial Research, and the particular Research Associations devoted to investigation into the problems presented by specific industries. The Department has rendered direct assistance to investigations both in pure science and in applied science at the Yorkshire universities. Details need not be mentioned. It has also supported and encouraged the work of three Research Associations which have their headquarters in Yorkshire. These are the British Cutlery Research Association in Sheffield; the Wool Industries Research Association in Leeds; and the British Natural Silk Research Association also situated in Leeds. The aim of these Research Associations is well known. Their importance as agencies for promoting applied science needs no explanation. They have been in existence a comparatively short time and have already, in spite of financial difficulties, accomplished work of outstanding value to their respective industries. The Cutlery Research Association has expended until recently about £3,000 per annum. A good deal of its work is done by firms in the city. The Wool Industries Research Association has a relatively large establishment in Leeds—a staff at present of 17 graduates and 35 Research Assistants; and expended on its work in 1931 about £19,000. The Silk Research Association has a paid staff of 4 with 11 laboratory assistants attached; and expended in 1931 £2,500 on its work.

Doubtless as the work of these Research Associations continues, its value will be increasingly appreciated by those on whom they depend for financial support. Their aim is different from that of either technical colleges or universities in two respects. They are not teaching organizations, their aim is solely that of research, though entitled to give instruction: and they are for the most part concerned not so much with scientific investigation into the foun-

dations of the industrial processes as with the solution of particular problems and difficulties encountered by those who are engaged in the respective industries. The scientific staff of the Associations, however, are fully alive to the close connection between the solution of specific practical problems and scientific investigation into the foundations of the various processes involved in the industry with which they are engaged. Important fundamental research of this nature has been carried out, and only lack of means prevents more being done. On the other hand, it has been seen by those Research Associations situated in Leeds that mutual advantage could be gained by interrelationship and co-operation between the scientific staffs of the Associations and the cognate staffs of the University of Leeds. With this in view, a working arrangement has been effected between the University of Leeds and the Wool Industries Research Association and the British Silk Research Association. The laboratory of the latter Association has in fact from the beginning been situated within the buildings of the university. Research students may proceed to degrees by working within the laboratories of these Associations. Other students are also admitted to their laboratories for the purpose of investigations. It will be recognized that such a working arrangement at once makes for economy of resources in the common enterprise of advancing the interests and influence of applied science, and places the scientific equipment of a university at the disposal of those occupied with a specific range of industrial problems. There is, however, room for both types of research, that of the Research Association and that with which a university is primarily concerned. A university can hardly be expected to have the means or the staff to undertake systematically the investigation of all the practical problems and difficulties which constantly arise in the complex textile industries; and the practical industrialist cannot be expected to await or immediately to require in his daily business the solution of ultimate scientific questions raised by his industry. None the less, it is an obviously valuable extension of the work and influence of applied science in this area that the problems of industry should be investigated by Research Associations and University Departments in co-operation.

Turning now to another aspect of the subject, it may be of some interest to indicate what progress has been made in recent years in the extension of applied science in Yorkshire, taking applied science in the most comprehensive sense to include instruction in the technical colleges as well as the training in the Technological Departments in the universities. This can best be shown by a statistical comparison of the number of students in attendance and

the amounts spent on technical and technological education and research. Doubtless this is not a final test of progress; and it is certainly no test of the effect of applied science on industrial prosperity, with which, however, we have no direct concern. But statistics do reveal a tendency and indicate the extent to which the community at least believes in the importance of technical instruction in the technical colleges and teaching and research in the universities. We may take for purposes of comparison an interval of about twenty years, and will give statistics for the years 1913 and 1931.

The actual number of institutions supplying technical instruction of a non-university type has not appreciably cinreased during this period. In 1913 there were 40 municipal centres offering facilities of one kind or another for instruction of this character. Most of the institutions were in existence before that date, some of them during the last years of the 19th century. In 1931 there were 42 municipal centres providing such facilities.

The number of students in attendance upon courses of instruction in technical institutions in the area in 1913 was approximately 25,000; in 1931 approximately 54,000. These numbers include, in the case of certain institutions for which statistics have been supplied, some students not taking technical courses in the strict sense of the term. The numbers are, however, sufficiently approximate for our purpose.

The expenditure incurred on behalf of technical instruction in the Yorkshire area was in 1913 approximately £100,000; in 1931 approximately £400,000. These figures are subject to a corresponding qualification.

It may be of interest to mention particular areas for which comparable statistical data have been furnished. These data refer to technical education strictly, as well as to other forms of instruction given in technical institutions and evening schools—commercial instruction, art, etc.

	No. of Students in Attendance		Expenditure	
	1913	1931	1913	1931
West Riding County Council Administrative Area (the largest in Yorkshire)	13,500	31,100	£38,000	£144,000
Leeds	1,400	3,400	23,000	87,000
Huddersfield	1,600	3,800	12,000	39,000
Middlesbrough	700	1,400	1,500	14,000
Hull	1,300	3,400	8,400	33,000
Barnsley	1,000	2,000	3,200	11,000

Excluding the West Riding Administrative area, the areas mentioned are remote from one another, have a different industrial

milieu, and the institutions have each had a separate history under a different education authority[1].

These figures reveal a remarkable expansion of the work done for technical education of all grades during the last twenty years. It is not due solely to the policy of the education authorities, important as that doubtless has been in developing this field of their operations. It has had the support of business men, employers and employees, engaged in industries, and implies a growing recognition on their part of the value of the technically trained intelligence. Their interest has been sympathetic, and taken active expression in practical ways. They devote time, thought and money towards encouraging progress in this form of education. In most centres where technical instruction is given, business men are members of the governing bodies of institutions, act on advisory committees dealing with the various sections of the work, and in some cases act as part-time members of the teaching staff. They provide money for scholarships and prizes, and in many cases pay or refund the fees of the students belonging to their firms, or give increases of pay to employees who show promise as students. In many cases they allow employees to attend classes during the day without deduction of wages, and to take special courses in technical colleges at a distance from their own towns. They offer facilities to students to visit works. They supply books, materials, equipment and machinery etc. to the institutions, and have contributed generously towards the provision of new accommodation. The Constantine Technical College in Middlesbrough is the most recent example of private munificence in support of technical education. Joseph Constantine contributed £80,000 towards the cost of the building, and this was supplemented by £25,000 from local firms and others. The universities in Yorkshire have also played a part in promoting the work of the technical colleges and institutions. They provide in some departments evening classes of an advanced kind, and enable technical students to have the advantage of the valuable equipment at the disposal of the universities. They offer opportunities for further training to students who have completed a technical school curriculum. They train and supply qualified technical school teachers. In certain cases technical colleges are directly affiliated to the University of Leeds, and at Sheffield the whole of the work of the technical college is associated with the university.

1. It s perhaps worth while for purposes of comparison to state that for England and Wales as a whole the number of students in attendance at the same class of institution (technical, including Junior Technical, Art, Evening and similar schools) in 1914 was in round figures 860,000 in 1929 (the last year for which published statistics have been available) the number was 969,000. The payment made by local authorities for institutions of this type was in 1913 in round figures £1,800,000, in 1929 £3,500,000. For 1931 the sum is estimated to be over £4,000,000.

In the technical colleges the subjects in which technical instruction and cognate scientific instruction have been given are naturally those which bear directly on the industries carried on in the various cities and towns where the colleges are respectively situated. Some of these subjects are common to most of the colleges, others are confined to particular colleges. The technical subjects generally taught are those of Engineering, in one or more of its branches, Textiles and Mining. The technical colleges offering the greatest variety of technical training are situated, as might be expected, in Leeds, Sheffield, Bradford and Huddersfield; and of these Leeds claims preeminence in this respect, owing to the variety of industries carried on in the city.

In the universities applied science departments have in most cases a local reference; in some cases, e.g., the Coal Gas and Fuel Department, a connection with industries affecting the country as a whole; and in all cases an interest and a value beyond the locality of the university. A few of these departments have special endowments, e.g., the Livesey Chair of Gas Engineering at Leeds; or are specially financed, e.g., the Textile, Colour Chemistry and Dyeing Departments in Leeds have been maintained mainly by the Worshipful Company of Clothworkers in London; all are supported to a greater or less extent from the general funds of the universities, and receive assistance from the respective industries or public companies. Some of these departments were established in the first instance because of local or historical circumstances. For example, in Sheffield, renowned throughout the world for its scientific investigations into metallurgy, the local iron and steel industry owes its origin, not to the coal fields, but on the one hand to the steep fall of the river Don and its tributaries near Sheffield, which provided the necessary power to blow the hearths and drive the grinding wheels, and on the other to the readily available supply of charcoal from the thickly wooded slopes of the adjoining hills. In mid and northern Yorkshire, the wool trade, which appears to have been first developed by the monks of Fountain's Abbey in the 14th and 15th centuries, led to the establishment of the textile industry, first by hand and later on in factories built in the valleys where rivers provided the necessary water power. Leeds had long been associated with the wool trade and the textile industry, and hence from early days devoted attention to the study of the textile industries. On the foundation of the Yorkshire College, by good fortune the Worshipful Company of Clothworkers in London took a generous interest in its welfare, and by their assistance made possible the establishment of a Textile Industries Department.

Their munificence has enabled the University of Leeds to institute and maintain the only Textile Industries Department in any university in this country, and one of the best known departments in the applied science of Colour Chemistry and Dyeing.

Mining, Engineering in its various branches, and Fuel Technology and allied branches are common to both universities, the Department of Fuel Technology in Leeds University being the first of its kind in British universities. Metallurgy has now a specific Faculty of its own at Sheffield University, where also Glass Technology is located, the only applied science department of its kind in the country. The chemistry and technique of the Leather Industries are investigated in Leeds University in a department made famous by Proctor, in recognition of whose work there was founded by his admirers the Proctor Research Laboratory. Leeds is conveniently situated near the centre of the agricultural area of Yorkshire, and the Agricultural Department of the University of Leeds has played an active and important part in the development of scientific interest in agriculture in the whole country.

Students proceeding to degrees or diplomas in applied science generally take three years, and spend a considerable portion of the first two years on the study of the pure sciences which have a bearing on the particular applied science in which they specialize. During their course they usually spend some time, generally during the vacations, in obtaining experience of practical technique in works. Such experience as this is obviously important, and is necessitated by the difference between an academic laboratory and the practice of an industry, and also by the limitations of laboratory work. It corresponds to the training and experience acquired by a medical student in the wards of an infirmary as distinct from the laboratory and class-room of the Medical School. There may be a question whether an applied science subject should not be taken after a full degree course in the pure sciences. But this, however advantageous, is impracticable for lack of time and means on the part of the majority of students.

In all these applied sciences a steady volume of research work has been produced since the institution of the universities, in some departments to a greater extent than in others, and in certain cases with the help of special research grants from the industry or other sources, which supplement the limited financial resources of the general university funds. Reports on the research work done are usually published each year. Close contact between the industries concerned and the departments of the university is kept up directly and indirectly. Specific problems

raised by particular firms, local, national and beyond Great Britain, are constantly referred to the departments for investigation. Academic committees, composed mainly of representative men or representatives of Associations engaged in the industry, take a general supervisory interest in the work of the different applied science departments of the university, and thus link up the university in an indirect practical way with the industrial community. Most departments receive gifts of machinery and materials from time to time from those concerned with their industry.

The intimate relation between the staffs of the general science departments of the universities and those of the applied science departments is of the utmost advantage to both, as will be readily understood. Moreover, the applied science departments are becoming to an ever increasing extent interdependent, the work of one department being of direct assistance to another. Engineering, for example, serves the purposes of most applied sciences.

Both expenditure and staff in the various departments have greatly expanded during the last twenty years. In 1913 the total expenditure on the applied science departments in the University of Leeds amounted to over £16,700; in 1931 it amounted to over £58,700. In Sheffield University the corresponding figures are £12,800 and £37,300. This expenditure includes salaries and wages of staff, and departmental and laboratory maintenance. In Leeds in 1913 the staff, whole-time and part-time, in the applied science departments numbered 59; in 1931, 102; in Sheffield, 72 in 1913 and 105 in 1931.

The number of students in the applied science departments who graduate each year varies from department to department. In total these represent a steady flow of men trained and equipped to introduce the methods and spirit of science into the industries investigated in the universities. The effect of this on the prosperity of industry cannot, of course, be estimated: its advantage is undoubtedly cumulative. As a rule, few qualified students fail to find a place, sometimes a leading place, in the industry which has engaged their attention at the university. During the period 1913-31, of those who have passed through the various applied science departments of the University of Leeds, there have been over 400 in the Textile Department, about 300 in Agriculture[1] Engineering, over 200 in Colour Chemistry and Dyeing, about 85 in Leather Industries, and 72 in the Fuel Department. In the case of the University of Sheffield, over 200 have taken degrees

1. In addition to the university classes proper in Agriculture, the university supplies organized and occasional lectures in the county area. The number in attendance on the latter is indefinite but very large: in the case of the former the number was over 800.

in Engineering, Metallurgy and Applied Science, 63 have taken diplomas in Mining, Fuel and Glass Technology, and over 300 associateships have been given in Engineering and Metallurgy. With negligible exceptions, these university trained students have found their way into industry. It needs little imagination to realize the influence which such an accession of scientifically trained students to the ranks of the various industries must exert on the efficiency of their respective sphere of usefulness.

Research and post-graduate students in increasing numbers have been engaged on specific problems germane to the various departments, sometimes in co-operation with the Head of the Department, sometimes under his direction. In one department as many as ten research chemists and graduate assistants are engaged on research problems. In some cases special investigations have been started in a university, carried on for some years, and then undertaken on a larger scale either by a special Association inaugurated for the purpose or by some other institution.

The extent and the numbers engaged in research are sure to increase in the future as applied science progresses, as its value is appreciated, and the means for carrying it on increase. It is safe to say that in most applied science departments we are merely at the start of our investigation. In many fields applied science has not yet even begun investigation into the foundations of nature's available resources. New results in pure science create new possibilities for advancement in applied science. New achievements in applied science set new problems to pure science, and on the other hand suggest the possibility of new adventures in commercializing applied science. The resources of university general funds are limited, and are not likely to be greatly increased for some years to come. Accommodation is also a serious consideration. The generosity of those whose interest, financial and otherwise, is bound up with applied science must be relied upon, and if we judge by the past can confidently be trusted to promote further progress. Probably one of the most valuable developments in the future would be brought about if the universities were in a position to undertake investigations on a larger scale. It is well known that qualitative results vary with quantitative conditions. An illustration of this is found in the case of chemistry, and gives rise to the need for large-scale chemical investigations. There is no doubt that Chemical Engineering is a costly undertaking: but plant for research in this subject is a desideratum in any fully equipped department of technology. Again, aeronautical engineering is an obvious want in the universities of Yorkshire, and the demand

for it in the future may create the supply. Probably it may be found desirable, as the problems of applied science become more specialized, to economise resources by division of regions of investigation in the same field between universities, as is at present done in the case of different departments, Glass Technology being, as already stated, carried on in Sheffield, and Colour Chemistry and Dyeing in Leeds.

Enough, however, has perhaps been said in this short paper to indicate in outline the place, range, and character of applied science in Yorkshire.