

petroleum, fabrics and fibres, and others, and to medical science. Many of the subjects referred to in this account are discussed more fully in the papers contributed in honour of the Society's centenary, which, as mentioned, are to be published in the Society's *Journal*.

In conclusion, we may express the belief that

the Royal Microscopical Society has throughout its history sedulously pursued studies associated with problems of microscopic structure and function, and has contributed in no small measure to the development of the microscope as a scientific instrument, and to its applications in science and industry.

EDUCATION FOR INDUSTRY*

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THE evolution of industry involves a continual change in the character of the knowledge that must be applied by those engaged in it, if they are to achieve a continually increasing efficiency of production. How important this question of efficiency is to the whole community of an industrial nation may not always be appreciated. The material progress of civilization demands an increasing supply of manufactured products of all kinds. If they are manufactured at home, employment is increased and money is available for circulation. This affects eventually all the community and not merely those workers directly engaged in industry. It is therefore of vital importance that the transformation we speak of as industry shall be conducted with the utmost efficiency, and to achieve this the personnel engaged in it must be most effectively trained; which in its broadest sense means most effectively educated.

Industrial personnel can be divided into two main groups: manual and non-manual workers. The first requirement of the manual worker is practical handicraft skill, and of the non-manual worker specialized knowledge applicable to the function he performs in the particular branch of industry concerned. To satisfy these requirements well-organized schemes of theoretical and practical training must be made available to all those fitted to take full advantage of them.

There are four main classes of entrants into industry, namely, those who enter at the school-leaving age from elementary, junior technical, central and secondary schools; those from secondary schools who have attained School Certificate or Higher School Certificate standard; those who have had university training; and those adults who enter at any age and from any educational level. Of the first three classes, the university

group contains the smallest proportion of misfits. At the lowest entry level, economic need and local conditions of employment may, and usually do, determine the choice of vocation. In addition, there is still considerable social prejudice in favour of the so-called 'black-coated' occupations. The importance of vocational guidance in the early years cannot be too highly stressed, and although good work is being done in this direction much more is needed; it should in fact be accepted as a responsibility by every competent teacher. Such acceptance implies, of course, familiarity with local conditions and opportunities. One useful adjunct might be the keeping, from school entry age onwards, of a record of the particular characteristics, aptitudes and preferences displayed by the pupil. Such a record would be of considerable value at the time when discrimination is made between secondary, junior technical and junior commercial schools.

For those entering industry at the lowest stage there is, at present, little conscious preparation for industry from the educational point of view other than that in the junior technical schools. The practical industrial bias given in these schools, for at least the final two years, is of definite advantage. A much greater proportion of junior technical school pupils who enter industry advance rapidly than is the case with their fellows not so educated. Indeed the tendency is for many of them to be recruited to the ranks of foremen, junior managers, draughtsmen and so on, with the result that the equally important field of artisanship is not very well fed numerically from this source. Records of one factory, compiled over a period of years, show that whereas 64 per cent of the entrants from elementary schools became artisans, less than 10 per cent of the entrants from junior technical schools did so, in the same period.

The type of industrial training required for the manual worker who aspires to learn a trade or acquire a craft consists of a long period of practical

* From the presidential address to Section L (Educational Science) of the British Association, delivered at Dundee on August 31.

experience with the tools, materials and processes of his chosen trade or craft, and accompanying classroom education which may be secured by evening study in a local part-time institution, by part-time day training, or in a works' school during working hours. The character of these studies varies considerably, but it is becoming increasingly desirable that they should lead to National Certificates, as a course of this type provides sufficient basic technical knowledge. Moreover, it provides a good basis for further study for the youth who is worthy of promotion.

For those youths who do not aspire to technical employment and whose natural bent is of a more practical character, the workshop courses provide an admirable adjunct to their practical experience.

Those who enter industry at the School Certificate or Higher School Certificate level have usually had the advantage of a preliminary science preparation, which facilitates their acquisition of industrial process experience. Moreover, their higher general educational level makes it possible for them to attain staff positions where their more maturely developed powers of judgment and their social attributes are of advantage.

Those who enter after university training have already acquired a considerable amount of knowledge of the technological and fundamental principles required in the particular branch of industry they select. A high degree of specialization at this stage is extremely undesirable. It is of far greater value to be well versed in the fundamental principles of the selected and associated subjects. Indeed the latest tendency in industry is for any specialized training that may be required to be provided by the concern itself a year or two after entry.

Much attention is now being devoted to the problem of finding suitable personnel trained to undertake the increasingly difficult problems of management. This is a matter of vital importance in ensuring continuity of progress in manufacturing concerns. It is essential that the selected men should be given preliminary and widely applied responsibility before making use of such aids as the ancillary instruction now available in many technical institutions.

Recruitment for research work in industry is another case where the selection of personnel inherently suited for such work must be the basic factor. Methods of training research workers are beginning to evolve, but so far no recognized plan is established. In my own laboratories, general apprenticeship in the factory is followed by experience in several of the laboratories under the guidance of experienced research workers, supplemented by lectures on the work in their own and

associated fields by senior members of the department. In some cases such workers are sent back to a university or other research laboratory for further experience.

There is a natural tendency to concentrate attention on those engaged in some form of handicraft skill or technical operations for which particular education and training are required. It must not be overlooked, however, that there are vast numbers of young men and women engaged in clerical and other branches of employment in industry. For the most part, however, their education and training can be adequately satisfied by the existing facilities.

The normal trend of industry and its corresponding educational requirements can to some extent be forecast, though contingencies arising from an abnormal international political situation may disturb this.

New scientific knowledge with its technical application is likely to continue to be a determining factor in industrial development. Continual improvement in efficiency of production tends to reduce the amount of labour required, and to that extent accentuates the unemployment problem. On the other hand, out of scientific discoveries new products, processes and materials arise, and these, through the formation of new industries, contribute towards redressing the balance of employment. The film and the radio industries may be cited as examples of large-scale employment brought about by the technical application of scientific discovery. Such developments, however, emphasize the need for mobility and adaptability on the part of the personnel employed, because new industrial activities demand modifications to established handicraft technique as well as to the planning and organization of production.

It is apparent that the mechanization of processes, more particularly where repetitive work is involved, will become more extensive, and this should ultimately result in the securing of the necessary volume of production in shorter working periods—especially if employment could be more evenly distributed. Some of the time then available for additional leisure might be well employed in education of a cultural and social character and in physical training. By suitable planning it should be possible to reduce and eventually to eliminate the system of part-time evening study. The deficiencies of this system of technical education for those engaged in industry are well understood, but whether technical study is conducted in part-time day or part-time evening periods, the practice of compressing a large amount of highly specialized knowledge into intensive courses should be avoided.

While appreciating the present usefulness of courses such as those leading to the Higher National Certificate, particularly to those young people who have no other means of acquiring the basis on which to proceed to technical employment, such courses should, in a planned educational system, be considered as expedients only. They provide neither the time for original, critical, or constructive thought, nor the means of developing latent personal qualities by any form of social and corporate life; and above all it is important to encourage educational methods which develop ability to think independently rather than simply to add to a store of knowledge. That so many young people succeed by the existing methods is a tribute to the individual rather than to the system.

Certain industrial activities, notably those associated with supplies such as water, gas and electricity, are easily recognizable as public services. As time goes on there will be a growing realization that every industry is in fact a national service, although it may be conducted, as at present, by private enterprise. Considered in this light, the importance of employing every means of increasing the efficiency of industry becomes apparent. The conventional system of education is subject to control by national and local educational authorities; but there is no control over the equally important practical side of education for the industrial worker. No national means exist whereby a standard can be set for this phase of education, nor in fact are the resources for training in industry fully utilized.

The *laissez-faire* methods whereby the quality and extent of practical education of industrial personnel depends on a relatively few progressive industrial concerns compare unfavourably with the planned and more efficient methods that are possible in authoritarian countries. Under present conditions this weakness can be remedied only by more complete voluntary co-operation within industry. Such co-operative effort would relieve the burden that now falls upon a few individual firms. An effective way of stimulating this might be the remission of income tax on the money expended on such training. Control could be instituted by restricting the remission to courses approved by a suitably constituted authority.

The establishment in industrial firms of separate 'nursery' workshops in which the fundamentals of handicraft skill and machine operations are taught concurrently with the appropriate workshop instruction will become more widespread. A few schemes of this type are already in operation in private firms and in a number of Government establishments in Great Britain, while the method has been extensively developed in Germany and to a lesser extent in other countries.

The result of introducing manual training at an early age, such as exists in the educational system in the U.S.S.R., will be watched with much interest. In contrast to this, with the raising of the school-leaving age, the tendency in Great Britain will be for young people to enter industry for practical training at progressively increasing ages. This may involve a more intensive period of practical training, but the difficulties of this should be offset by the greater maturity of the trainees concerned, which the longer period of general education will ensure.

An educational problem that is already acute and will be even more so in the future is the supply of suitable teaching staff for the universities and technical institutions. Formerly much of the scientific and technical development relating to industry came from the universities. Due largely to the establishment of large-scale research by industrial concerns and to the great expansion of their technical staffs, the initiative in progress has passed to industry, and many scientific workers who previously found their vocations in academic life are now attracted to scientific and technical employment in industry. The result is that in those faculties in which the work has a technological bearing, there is a great shortage of personnel available for teaching, so that the time is opportune for the technical institutions and universities to consider a long-term policy as regards selecting and training those who will eventually become the academic leaders.

The practical industrial side of this training is of paramount importance. In this connexion co-operation should be arranged with industry to provide a suitable range of practical experience without the permanent absorption of the personnel so trained. Industry has already shown its willingness to co-operate with education in this respect by providing short 'refresher' courses for those in academic employment who have little opportunity of maintaining close contact with industrial developments. The technical knowledge and experience of eminent technologists in industry might well be utilized more completely than at present by co-opting such men to the professorial staffs of universities and technical colleges, and thus augmenting, for special courses, the existing teaching facilities. New technical processes now arise so rapidly from scientific discoveries and become so promptly established in industry that the text-books used for teaching purposes can never be completely up to date. The introduction of post-advanced courses in the Lancashire area appears to be the correct solution to this problem. These courses, which comprise short series of lectures on specific technical subjects, are given mostly by experts in industry and are conducted on a basis of exposition and discussion.

The greater availability of technical scholarships and fellowships might well serve as a means of attracting suitable personnel to industrial employment. The extension of fellowship facilities available for those who seek experience abroad is extremely valuable, particularly if these are awarded to men who have already had sufficient experience to know definitely in what particular directions they wish to supplement their existing knowledge. In the past, many educational opportunities of this type have not been used to the best advantage due to the immaturity of those receiving the awards, who have not had sufficient experience to appreciate fully that educational and industrial methods can never be transferred wholly from one country to another because social and economic conditions differ. Some industrial organizations have established research fellowships, whereby university staffs can spend time in industrial research organizations, which provides experience of inestimable value to the fellowship holder on his return to academic life.

As yet there is no clearly defined and assured path by which a youth can proceed through the various stages of education into industrial employment. The national system of education provides the means whereby those of suitable ability can obtain education and training up to and including the university or technical college level, but the practical training in industry and an assured start in a job is at present fortuitous. In this direction there is room for greater co-operation by industry to ensure the completion of the industrial training

and a start in the chosen career. Such an arrangement would give direction and impetus to the various stages of preparation between school or college and industry, would cut down some of the time spent in obtaining what may be unnecessarily detailed technical knowledge, and moreover would relieve both the youth and his parents of a good deal of anxiety.

Greater co-operation than at present exists between education and industry is essential in regard to the syllabuses of workshop and technical studies appropriate to the educational level at which entrance into industry is made. Equally also, co-operation is needed to ensure the adequacy and up-to-date-ness of the laboratory and workshop equipment of the technical institutions and universities.

In this address I have purposely stressed the technical aspects of education for industry, since these to a considerable degree serve also as a basis for the industrial education of the personnel in those branches of industry not directly of a technical character. In so doing I am acutely conscious of the risk that, speaking as an industrialist, I may convey the impression that industry is concerned with the education of its personnel in a narrow sense only. This is far from being the case. All education should be on the most liberal lines, and even to meet the urgent needs of industry no technical specialization should be permitted which excludes the possibility of time being devoted to broadening the mind and equipping the individual to play his part most worthily in the community in which he is placed.

GAS PRODUCERS FOR MOTOR-CARS

THE appearance on a road in the London district of an omnibus with a trailer carrying a gas-producing apparatus to provide gas as fuel for its engine is a spectacular event which marks an important stage in mechanical propulsion in Great Britain. Although the method is by no means new, its adoption, even if only on an experimental scale, by a responsible authority on one of its public services, raises it from the category of the practically neglected to a position as one of the recognized possible alternatives to the use of liquid fuel. The trailer is not an essential part of the apparatus, and as soon as practical details have been settled by experience it will be possible to embody the gas producer in the vehicle so as to constitute a self-contained unit; but in the case of the existing pattern of omnibuses there is no surplus space in which such an apparatus can be

placed. In the case of the private car or delivery van, there is usually room for the required size of gas generator and little difficulty need be experienced in mounting it and its accessories quite conveniently.

In the issue of NATURE of May 6, p. 771, some notes were published on a paper read before the Institute of Fuel by Goldman and Clarke Jones entitled "The Modern Portable Gas Producer" (*J. Inst. Fuel*, 12, 63, Feb. 1939). The authors argued in favour of official recognition of portable gas producers as a means of supplying power for motor-vehicles. Now, nearly twelve months later, the argument for recognition is greatly strengthened, for economists have assured us that transport is the life-blood of modern conditions. Yet now transport is greatly restricted and, for lack of petrol, many cars have