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SCIENTIFIC AND TECHNICAL MAN-POWER IN BRITAIN

AMONG the specific issues of policy on which the Advisory Council on Scientific Policy was asked to make recommendations shortly after its first meeting in March 1947 were the arrangements for securing an adequate flow of scientific man-power to meet the needs both of Government and of industry. One section of the Advisory Council's first annual report deals with this problem in some detail, and may well be regarded as the most important section of the report. Since the Barlow Committee recommended in May 1946 that the output of scientific workers should be doubled so as to provide about five thousand every year, it has become apparent that attainment of this expansion within the immediate future is improbable, if not impracticable under present conditions. Furthermore, while on one hand the desirability of an expansion at the recommended rate has been challenged on the ground of the probability of the supply exceeding demand, on the other, fears have been expressed that too large a proportion of the available new scientific talent is being attracted to the Government services and that industry is not obtaining the recruits it requires.

In dealing with this task of keeping under review the probable demand for scientific man-power and the measures being taken to meet it, the Advisory Council on Scientific Policy investigated four primary questions: the number of scientific workers and technologists already available; whether the prospective supply of such men and women in the coming decade is likely to meet the expected demand, and, if not, what further steps should be taken to increase the output; and whether the present distribution of scientific man-power between defence and civil requirements is satisfactory. The last of these is clearly the most important question at the present time; but the answer we give to it must depend partly on the situation revealed by the examination of the first three questions. In regard to the first of these, the Advisory Council has discussed with the Ministry of Labour and National Service the possibility of arriving at a more accurate estimate of the existing number of qualified men of science and technologists than the rough calculation of 55,000 given by the Barlow Committee in 1946. The Ministry doubts whether the Central (Technical and Scientific) Register ever included more than about 85 per cent of the qualified scientific man-power in Great Britain, and the Advisory Council accordingly asked the Ministry to make a new survey with the view of ascertaining the numbers available at the present time.

A large number of replies have now been received to the questionnaire issued at the end of October 1947, and analysis of the results is expected to provide a very useful picture of the scientific man-power now available in Great Britain, with full details of the experience, qualifications and occupations of those covered. Further detailed reviews of the man-power position in particular fields of science are being carried out by the Ministry of Labour, and these reviews should also contribute to the more

difficult question of estimating the prospective demand for scientific workers. Some of the recent inquiries, such as that carried out by the Industrial Research Committee of the Federation of British Industries, are admittedly inadequate, and the figure of 70,000 given by the Barlow Committee as the minimum demand for scientific men in the United Kingdom and in the Colonial Service has since been questioned, as well as the further estimate that the effect of raising the school-leaving age and the increasing need for qualified workers in Government service and industry would raise this figure to 90,000 by 1955.

The Barlow Committee estimated that unless the output of newly qualified scientific workers was raised from its pre-war level of about 2,500 per annum to 5,000 we could not expect more than 64,000 to be available by 1955. According to the Advisory Council, the latest figures which have been obtained from the universities indicate that this level has almost been reached and that the present output, if maintained, is therefore likely to meet the anticipated demand. Against this view, it has been stated that the Universities of Oxford and Cambridge will only be able to admit about one in twelve of the student applicants for the academic year beginning this autumn. The Vice-Chancellor of the University of Manchester, Sir John Stopford, has spoken of intolerable overcrowding there, and has told the University Court that the number of students, at present 5,460, might reach 6,000 in October, but after that would have to be kept appreciably below 5,000 until the building programme was under way.

The shortage of accommodation, which has existed since the end of the War, for entrants from school has been due essentially to the policy of giving preference to ex-Service men; but the procedure has naturally reacted harshly on members of the younger generation too young to be called up for several years service in the Armed Forces. The waiting list of ex-Service men with a claim for preference is not yet exhausted, and the majority of those already admitted have still to complete their courses. While this position obtains, even if the standard of acceptances from school reaches a much more satisfactory level than one in twelve, not only must many young aspirants to a university education be disappointed, but also, and equally important for the assumptions of the Barlow Report, the age structure of the intake of scientific workers will be affected adversely, and a longer time will be required before the level is stabilized at whatever figure, whether double or treble the pre-war, for example, may be deemed desirable.

This factor may, however, prove of minor importance compared with the others, such as building extensions and the assembling and training of the teaching and research staff to deal with the increased number of students, which are involved in implementing such a long-term policy as that recommended in the Barlow Report. A Committee appointed by Nuffield College, in its report "The Problem facing British Universities"*, is of the firm opinion that, until additional financial resources can be translated into buildings and equipment, and additional staff collected, the doubling of the university population contemplated by the Barlow Committee is not possible, and even the present increase of a half over pre-war figures is excessive. The provision which the universities can make for other needs—extra-mural teaching, intra-mural part-time teaching, advanced research, and the wide range of advisory work exacted by the Government from university staffs to-day—is stretched to the utmost.

The Nuffield Committee statement casts a very critical eye over the demands for university expansion, and although the Committee appears to be sceptical as to the justification for doubling or trebling the university population, it is unfair to suggest that it is opposed to expansion. It is concerned rather with the best way of dealing with an increased demand in the immediate future, and with the dangers which may result from allowing limited and sectional pressures to distort the balance and scale of university provision. It casts few doubts on the employability of more graduates in the national life; but it is concerned as to the maintenance of the sanctity of university life.

The significant factors with reference to the report of the Advisory Council on Scientific Policy which are stressed by the Nuffield Committee are that the present demands for university expansion represent many conflicting and unco-ordinated pressures. In the aggregate, the estimated requirements of the professions, Government departments and industry for graduates represent a 60 per cent increase on the 1938 numbers. What does not appear to have been considered is how all these demands can be met without fundamentally altering the character and purposes of university education, particularly during the next ten years, when the shortage of teaching staffs is the most critical factor.

It is with this danger in university expansion that the Nuffield statement is fundamentally concerned. It admits the need for expansion, although it reserves judgment as to the magnitude required. It calls for better planning of existing resources, and for more thought about the aims and fruits of a university education. It suggests that before deciding when and how to meet some of the sectional demands for expansion, we should first consider those demands in the light of the fundamental purpose of the university. We may need a re-statement of the principles that should govern the life and work of a university if the demand for training for a career is not to be allowed to distort both the development and the functions of the universities.

The Nuffield statement puts these questions; but it does not attempt to indicate the answers. Its constructive suggestions are designed rather to ease the immediate pressure on the teaching staffs, and two of these are open to serious objection. The proposal to push back to the secondary schools a good deal of the instruction which is at present given in universities runs counter to a fairly general complaint that the schools are already giving much specialized instruction that should properly be given

* Nuffield College. The Problem facing British Universities. Pp. 131. (London: Oxford University Press, 1948.) 5s. net.

in the university. Certainly any increase in the influence of the university on the content of the school curriculum cannot be viewed without some concern that it may be detrimental to the interests of the many scholars who do not proceed to a university at all.

The second proposal is that universities in Britain should leave to the specialized institutions and technical colleges a good deal of the higher professional training that in the United States is undertaken by the universities. The Nuffield College Committee has in mind particularly the development of advanced schools for the study and teaching of engineering and other technological subjects and for the professional preparation of teachers, clergy and possibly others. The development in the United States as well as in Germany and some other European countries of such specialized institutions for advanced study and research is *prima facie* evidence that the suggestion deserves to be examined carefully. The Massachusetts and California Institutes of Technology and the *Handelshochschulen* of Berlin and Stockholm have assembled staffs and made contributions to research and teaching which few universities surpass. What chiefly distinguishes a university from them is a wider range of studies and a less specialized purpose.

Nevertheless, the separation of the study of engineering and other technological subjects from the universities and concentration in special schools, however closely located to the universities or friendly the association with them, has real dangers. In the first place, segregation of engineering and technological students in this way deprives them of the great benefit of a life shared with students in other fields, and may well encourage the narrowness of outlook so often condemned in the specialist. Conversely, not only have the students of engineering and other branches of technology a contribution to make to the corporate life of the university, sometimes out of proportion to their numbers, but also the teacher and investigator in these fields would, by such segregation, be deprived of the fertilizing and stimulating influence of close contact with colleagues working in such fields as mathematics, physics, chemistry and geology.

The first need, as the Nuffield College Committee rightly points out, is to define the specific function of the university and relate it to the functions of other institutions. In this matter of technical training, too, we need not only to be clear as to the justification for university facilities for any particular branch of professional or technological training, but also we need to recognize much more frankly that most occupations involve so restricted a range of theoretical or scientific knowledge that their technique can be acquired just as effectively and much more economically in the occupation than in a university. That is a consideration which bears closely on the correct distribution of scientific man-power, with which the Advisory Council on Scientific Policy is concerned.

A second conclusion reached by the Nuffield College Committee also touches that problem. Whatever the demands made on the universities, there is no possibility of meeting them unless the universities can draw from the schools a sufficient supply of undergraduates to be trained in accordance with those demands. Earlier in its report, the Committee endorses the view of the Barlow Report that in the present phase of expansion the universities must, so far as they are able, give the first priority to increasing the supply of university teachers and research workers. It then points out in this connexion that the fulfilment of even the sectional professional demands that are being pressed depends on the maintenance or improvement and extension of the general education given in secondary schools, and in particular that the universities must do all in their power to ensure that the schools can secure a regular supply of mathematicians, graduates in English and other languages, the classics and in science.

Complaints have been voiced that just as an excessive proportion of our scientific man-power is entering Government service rather than productive industry, so the staffing of schools with honours graduates in science of high ability is becoming increasingly difficult because of the more attractive and remunerative conditions in industry.

That is clearly a matter to which the Advisory Council cannot be altogether indifferent, although in its present report it merely considers the distribution of scientific man-power between defence and civil requirements. The question of higher technological training has been reserved for discussion in a separate report, and the survey of higher technical and other specialized institutions included in the Nuffield statement should prove a useful contribution to that discussion. The Advisory Council takes up the query raised by the Select Committee on Estimates as to the justification for the present distribution of Government research funds between civil research and defence research, and gives the estimate of about 13,700 scientific workers engaged in civil research as against 5,500 in defence research. The former figure includes 10,000 in industry, 2,500 in civil Departments of State and 1,200 in the research associations. The Advisory Council comments that much defence research and development is carried out by industry, while many scientific workers employed by the Government are concerned with subjects such as aeronautics and radar which have important civil applications, even when research and development are undertaken purely for defence purposes. The comparatively high Government expenditure on defence research as compared with civil research is due partly to the fact that the Government has to undertake directly or by contract all research or development for defence, whereas the main effort on the civil side comes from industry, and partly to the high cost of provision for development, design and prototype production in the defence field.

The Advisory Council has thus only touched the fringe of the general problem of scientific man-power, and in particular the question of distribution deserves rather fuller examination. The estimates of distribution in themselves merit analysis: on the figures quoted, qualified scientific workers employed by the research associations represented roughly some ten per cent of those engaged in Great Britain's total

research effort, a proportion sufficiently high to warrant some examination of the question whether it yields a sufficient return in comparison with other forms of research effort. The whole question has a close bearing on the prospective supply, and it may well be found that the promised report on higher technological training will provide the occasion for a more adequate discussion of some of these issues, which require to be resolved before the form of university expansion over the next few decades is finally moulded.

CHRISTIAN HUYGENS

Christian Huygens and the Development of Science in the Seventeenth Century

By Dr. A. E. Bell. Pp. 220 + 7 plates. (London: Edward Arnold and Co., 1947.) 18*s*. net.

FOR many the most fascinating period in the history of science is the second half of the seventeenth century, the time when the foundations for the vast structures of to-day were laid with extraordinary sureness, solidity and speed. Newton, of course, was the supreme figure, a genius whose pre-eminence has been emphatically avowed by all men of science who have closely studied his achievement. The age was, however, rich in figures of outstanding gifts and accomplishment, and among them Christian Huygens holds a foremost place. He was, incidentally, one of the few to whom Newton paid generous tribute. Pemberton records: "But Sir Isaac Newton has several times particularly recommended to me Huygens's stile and manner. He thought him the most elegant of any mathematical writer of modern times, and the most just imitator of the antients . . .", the "antients" for whom Newton always expressed the greatest admiration. In the "Principia" he refers to "Sir Christopher Wren, Dr. Wallis and Mr. Huygens, the greatest Geometers of our time", and, acknowledging the gift of a copy of the "Horologium Oscillatorium", he writes ". . . Mr. Huygens's kind present, which I viewed with great satisfaction, finding it full of very subtle and useful speculations very worthy of the author. I am glad, that we are to expect another discourse of the Vis Centrifuga." Dr. A. E. Bell, whose book is before us, quotes the familiar "What Mr. Huygens has published since about centrifugal force I suppose he had before me", and adds "wrote Newton with some chagrin", which seems to be a quite unjustifiable comment.

That Newton had a just appreciation of the work of Huygens and fully understood it is significant, because Huygens signally failed to comprehend Newton's full achievement, although he realized Newton's greatness as a mathematician and as an experimenter. He criticized Newton's fundamental work on colour because it did not explain the ultimate nature of colour—"Besides, if it should be true that the rays of light, in their original state, were some red, others blue, etc., there would still remain the great difficulty of explaining, by mechanical principles, in what consists this diversity of colours". He did not understand Newton's "But to examine how Colors may be explained hypothetically is beyond my purpose". Huygens himself wrote little about colour, since the problem as he conceived it, to find a mechanical explanation, seemed to him intractable: "I do not think", he wrote, "that it would be easy to show what makes red or blue colours, nor am I much impressed in this matter by the Cartesian proofs. Certainly it has little or nothing to do with the geometrical method of reasoning."* He may not have been impressed by Descartes' particular views on colour, but nevertheless he himself was seeking a Cartesian type of 'explanation'. Again, he could not accept Newton's gravitating forces acting at a distance; but, although he rejected Descartes' particular way of explaining gravity by swarms of subtle particles, he himself published as late as 1690 a scheme which accounted for terrestrial gravity by a shell of particles round the earth behaving in a somewhat different way from that devised by Descartes. He never, apparently, really understood the essential nature of the advance made by Newton in his great hypothesis of universal gravitation.

To say this is not to disparage Huygens, whose fundamental achievements make a formidable list. His pendulum clock was the first accurate timepiece, and was based upon a thorough mathematical study of the compound pendulum and of oscillations in general; his discussion of centrifugal force constituted a fundamental advance in mechanics; his discovery of the rings of Saturn, a brilliant piece of observation, was conditioned by the great advance which he made in the construction of the telescope; his construction for the wave front by what is known as Huygens' principle is fundamental to physical optics and his treatment of double refraction showed the way for subsequent advances in crystal optics. This, which is only part of his record, is a sufficient performance, without crediting him with the wave theory of light, for which, in the ordinary sense, he can scarcely be held responsible. He is one of the really great figures in physics, and it is quite time that there was a book on him in English.

Dr. Bell's book is divided into two roughly equal parts, the first dealing with Huygens' life and the second specifically with his scientific work. This arrangement has the disadvantage that it leads to a certain amount of repetition, which even extends to a double use of the same phrases and quotations. The biography is simply set down, with a good discussion of the Cartesian influence, which, in spite of the fact that Huygens often disagreed with Descartes on mechanistic details, always remained strong. There is the usual denigration of Hooke: it is, of course, perfectly clear and just that Hooke was incapable of the beautiful mathematical development in which Huygens excelled; but it is not correct to say, as the author does, that Huygens showed as wide a range of activity. I can only suppose that he has forgotten Hooke's work in geology, physiology and architecture, as well as the extraordinary scope of his invention.

The matter of aerial, or tubeless, telescopes is not very clearly handled: the original suggestion came from Auzout, and, so far as I know, no successful use was ever made of them, as anybody who has tried to set up even a model can readily understand. Huygens presented to the Royal Society in 1691 an object glass of 121 ft. focal length, with eyepiece and subsidiary equipment for an aerial telescope. Somewhere about 1844 Admiral Smyth thought of trying to erect it; "the trouble, however, promised to be so much greater than the object appeared to

* "Colores autem quid puniceos faciat aut ceruleos non facile ostendi posse existimo; neque hic multum Cartesianis demonstrationibus permoveor. Certe ad Geometricas rationes minime pertinet."