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MATHEMATICAL TECHNOLOGY OR QUANTITATIVE MATHEMATICS

WE publish in this issue an article by A. Erdélyi and John Todd, entitled "Advanced Instruction in Practical Mathematics", which follows an earlier article by D. H. Sadler and John Todd (*Nature* of March, p. 571), "Mathematics in Government Service and Industry : some Deductions from the War-time Experience of the Admiralty Computing Service". They claim that it has now been fully demonstrated that there is a need, in Government departments such as the Admiralty, the Ministry of Supply and Aircraft Production, and in industrial research associations or research departments of engineering or other firms, for a new type of mathematician, whom Dr. N. W. MacLachlan has called a 'mathematical technologist'. Such a man will have a good knowledge of academic mathematics, but in addition will know how to apply this knowledge to obtain a complete approximate solution, with full numerical calculations, of an engineering or other problem. Much of modern academic mathematics is of a qualitative nature. We prove that a solution of a problem exists, under certain conditions, and that this solution has certain properties, such as breaking down at specified exceptional points. The mathematical technologist will not be ignorant of this, but will supplement it with detailed quantitative knowledge, giving all the information required to any desired degree of approximation. So far the universities of Great Britain have done little or nothing to produce such men. What should be done about it ?

Before considering the proposals put forward by Mr. Todd and others, all of whom agree in their general objects, we must face the fact that many mathematicians of the greatest eminence will view such proposals with reluctance. For example, Prof. G. H. Hardy, the acknowledged leader of British pure mathematics, to whom most of the ablest young mathematicians have, for many years, looked for guidance and inspiration, divides mathematics into "real" and "trivial" ("A Mathematician's Apology", Cambridge, 1940). By real mathematics he means that which has permanent æsthetic value, for example, the best Greek mathematics. This mathematics "is eternal because the best of it may, like the best literature, continue to cause intense emotional satisfaction to thousands of people after thousands of years". Such mathematics includes not only Fermat's investigations into the theory of numbers and other work in pure mathematics, but also Einstein's theory of relativity, and Dirac's quantum mechanics. On the other hand, Prof. Hardy describes as "trivial" nearly everything that could be called laboratory mathematics, such as the work of gunnery experts and aeroplane designers. He admits that ballistics and aerodynamics demand a quite elaborate technique, so that it is perhaps hard to call them "trivial", but they are described as repulsively ugly and intolerably dull. It is not quite clear how far Prof. Hardy has been influenced by his appreciation of beauty, and how far by his dislike of war. Plato, on the other hand, advocated the study

of geometry not only for its permanent æsthetic value, but also for its usefulness in war. Both Plato and Prof. Hardy agree in disliking practical or mechanical applications. Plato would leave these to an inferior class without political rights, and Prof. Hardy to the garage mechanic. Really the Greeks were the more logical, for the philosopher cannot exist without the productive efforts of either slaves or of the machine. It is not contempt of human values, but a deep respect for them, that leads us to develop the machine as the only way of making possible a tolerable life for all. To develop the machine we need the technologist, and every branch of science must be called upon to make its contribution to human well-being.

But this contribution need not be a sacrifice without hope of reward, even from the point of view of abstract thought. Archimedes, the greatest mathematician of ancient times, who turned his attention to ballistics when it was necessary to defend his homeland against the invader, opened up many new and fruitful lines of development of mathematical theory. His genius was apparent in his disregard for the narrow limitations laid down by Plato. Gauss, "the prince of mathematicians", is revered for his researches in the theory of numbers and other branches of pure mathematics; but he was also greatly interested in calculating the orbit of the planet Ceres. His interest in practical surveying led to his beautiful theoretical researches on the differential geometry of surfaces. Why should any mathematician think it degrading to follow in the footsteps of Archimedes or Gauss?

We have thought it worth while to deal, at some length, with the possible *a priori* objections to the proposals of Mr. Todd and others, before examining in detail the proposals themselves, because once the desirability of the existence of mathematical technology is admitted, the case they make out can scarcely be denied. They point out that the need for training in computational mathematics was emphasized by the Assistant Director of Scientific Research in the Admiralty in 1942. Earlier in the War, great assistance had been given to the Admiralty and to other Government departments by the Nautical Almanac Office. When the work continued to expand, Mr. Sadler, superintendent of that Office, was called in to make an investigation, and made proposals which eventually led to the formation of a Mathematics Division of the National Physical Laboratory. This will be a permanent organisation, for peace as well as for war.

The question arises how the permanent senior staff of such an organisation are to be trained. To a certain extent, good mathematicians could pick up the technique by actual experience in the National Physical Laboratory itself. But this is not really satisfactory if new processes are to be devised, for the conditions of work in the Civil Service, especially for work which demands a high degree of accuracy, may not be the most suitable for innovations or research. Moreover, there are the somewhat similar needs of workers in any of the increasingly numerous industrial research associations. It would seem that systematic courses in the subject, such as could be offered by a university or institute of similar standing, would best meet requirements.

The greatest mathematical centre in Great Britain is the University of Cambridge; and it now has a Mathematical Laboratory, which is reasonably well equipped, and active workers who understand the importance of mathematical technology. It is not too much to hope that a flourishing post-graduate school may grow out of the work of this Laboratory. There is also the Imperial College of Science and Technology, London, which, as shown by Prof. S. Chapman's article "University Training of Mathematicians" (*Mathematical Gazette*, 30, 61; 1946), has a competent staff who have sympathy and experience with work of this sort. It is true that Prof. Chapman was describing a modification of the undergraduate course which has produced good results, whereas Mr. Todd and his associates prefer a post-graduate course in computation following an honours course in mathematics of the usual type; but the general point of view is so similar that it should be easy to devise concerted action.

Now that the University Grants Committee has new terms of reference, which empower it to advocate a positive policy, it might well consider the establishment of an institute devoted to mathematical technology or quantitative mathematics. The term "advanced practical mathematics", used by Mr. Todd, has an unfortunate association with instruction in the use of formulæ without proof, sometimes given in technical colleges, and so require careful consideration. In the beginning, at any rate, the organisation should be elastic. In addition to complete courses for those who are desirous of taking a full course of training, there should be short courses to attract mathematicians who, though suspicious, might be willing to investigate a new aspect of their subject. Whether such an institute should publish monographs, or a journal of its own, and how far it should install elaborate calculating machines of mechanical or electronic types, are matters for the future. What does seem clear now is that a start should be made as quickly as possible.

APPEAL TO CLIO

History is on Our Side

A Contribution to Political Religion and Scientific Faith. By Joseph Needham. Pp. 226. (London: George Allen and Unwin, Ltd., 1946.) 8*s*. 6*d*. net.

UNDER the title "History is on Our Side", Dr. Joseph Needham has brought together twelve essays and addresses written or delivered between 1931 and 1942, some of which were revised during his stay in China. Most of them display the omnivorous character of Dr. Needham's reading, and some of them have the charm and persuasiveness that marked his earlier book, "Time: the Refreshing River". But in spite of a certain spiritual quality, they are rarely so convincing as his earlier book. They lack unity, and the book as a whole is a rather confused mixture of science, politics, religion and philosophy in which the enthusiasm of a convert has warped the judgment and critical faculty that one would expect of a scientific man of Dr. Needham's standing. Dogmatism